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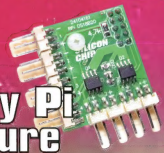

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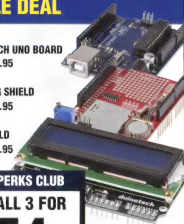

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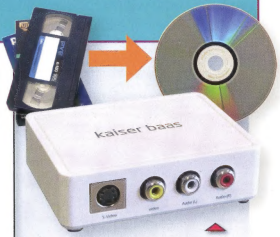

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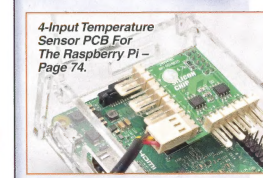

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Publisher's Letter

The visual spectacle of thunderstorms and auroras

Ever since I was a young boy, I have been fascinated by thunderstorms and their visual spectacle. Indeed on many a stormy night at home I love to go upstairs, open up all the blinds and watch the show. Our home has panoramic views over the sea and the show can often be spell-binding as I watch vast cloud formations flicker and flash, often lighting up the sea and coast as bright as day. And while many people would probably refer to these displays as "sheet lightning" (if they think about them at all), they are far more than that. Yes, the cloud formations do light up and flicker from one cloud to the next but that is partly because the direct lightning strikes are obscured from view by the clouds themselves.

But if you look more closely you will often see that most of these strikes are visible, whether from cloud to ground or from cloud to cloud. And often those cloud to cloud strikes themselves are truly spectacular, especially when you realise that they can easily span a distance of 20km or more. And then there are strikes which don't appear to hit the ground at all but merely spear off into the distance or even straight up into space. How does that work?

We now know that what we see of thunderstorms is only a small part of the show and that for every discharge to earth, there are equal discharges out into space, far, far, above the stratosphere, as described in our feature article on Atmospheric Electricity by Dr David Maddison, in this month's issue.

But the spectacle of a thunderstorm is even more amazing when you realise that the light show is continuous and lasts for many hours. In truth, a big storm can last for days. I will often go to bed in the evening while a thunderstorm is raging outside and then get up in maybe five or six hours later and the storm will still be visible far out to sea or even beyond the horizon, maybe more than 100km to the east. And if I bothered to follow it on the Bureau of Meteorology's weather radar, I could still see the storm several days afterwards until it petered out maybe 1000km away.

All that time, there would have been many thousands of lightning strikes per hour; no wonder the light show is continuous! And of course, the evidence of all that electrical activity is not confined to the immediate locality of the thunderstorm which may easily range over an area of more than 100 square kilometres or a great deal larger. In fact, it is merely a tiny part of the global electrical circuit (GEC) and every lightning strike has effects which ripple right around the planet. And then we read in this month's issue about Schumann resonances (between the surface and the ionosphere) and how those resonances are triggered by lightning strikes. Think of that – the GEC ringing like a bell due to lightning and that is happening all the time, around the world. And it has been like that for billions of years!

And the GEC itself is heavily influenced by the Sun and the most visible evidence of that is in the auroras which are visible over vast areas of the polar regions. No wonder there is growing tourism to view those wonderful spectacles. And then think about the Sun-induced violent geomagnetic storms. They utterly dwarf our Earth-bound storms and can have far more reaching effects as well.

With all that to consider, the ancients were right to tremble as the power of storms was unleashed upon them. Yet they did not know even a fraction of what was really going on, just as we today do not fully understand the mechanisms of storms. What we do know is truly enthralling and mind-boggling.

Next time a storm is brewing, even before it arrives in your locality, take the opportunity to watch and wonder. Be enchanted.

Leo Simpson

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Automatic starter for cars comprehensively panned

Regarding the Circuit Notebook entry, "Automatic Starter Circuit For Cars", published in the April 2016 issue, this is a Very Bad Idea.

If wired as per the circuit diagram, it will auto-start any vehicle (manual or auto) IN ANY GEAR. If it is a cold start, the fast idle that occurs under this condition will, unless the handbrake is working 100%, cause a situation I would not like to see.

For example, the car is parked and left in Reverse, Drive, 2nd or Low, the parking brake is off, or applied but perhaps not fully or it's out of adjustment. Put the key in and turn it to the on position, say from outside the car (to check the fuel gauge, listen to the radio, check the digital odometer etc).

Then the engine starts, fast idle kicks in, and off she goes, where she stops nobody knows . . .

Or if you are driving down the road minding your own business at 100km/h and the fan belt breaks, the starter promptly engages and the reduction gearing (which is designed to allow the starter to spin at several thousand RPM in order to crank the engine at perhaps a hundred RPM) now works in reverse, causing the starter to over-speed and suffer catastrophic involuntary disassembly due to the centrifugal forces on the armature, or the starter motor one-way clutch disintegrates – or both.

I think by the time you figured out what happened and decided to turn off S1, the remains of the starter motor drive mechanism would be rattling around in the bell housing or lying on the roadway.

Or consider this: you go to start the car in the garage, nose to the wall but the battery appears to be flat. You turn the ignition key on and off a few times in case it's not making contact but leave the ignition switch on. No dash lights as the battery is dead flat – you think. You jiggle the gear lever between Park & Neutral, with no luck, and leave the selector in reverse.

You take the handbrake off, to push the car back so you can get to the battery, which is under the bonnet. But you find the battery terminal is just loose and when you wiggle it, it suddenly makes contact.

As the ignition switch is on, and the transmission is in reverse, the auto start kicks in, then as the engine is cold so the idle speed comes straight up and you watch the car start up, back out of your driveway, across the road, into the neighbour's fence, and then into their (hopefully unoccupied) living room.

And while you watch this you keep thinking what would have happened if you had left the gear selector in D instead as you were standing in front of the car when you wiggled the battery lead . . .

I know Google autonomous cars are on the road right now but this is really not quite the same thing – it is unintended uncontrolled autonomous behaviour.

There is a very good reason why the manufacturers disconnect the radio and other sensitive equipment during engine cranking; apart from reducing parasitic loads during the cranking cycle it's to protect this sensitive equipment from the not insubstantial surge that the starter dumps into the vehicle wiring harness when the starter has power removed once the engine starts.

It is clear from the text that the author is aware of at least some of these

Optimum alignment for solar panel

I am bemused by your advice on "Positioning the Solar Panel" (March 2016, page 66) that "the panel's inclination should be roughly 23° up from the horizontal . . ."

The optimum alignment is facing True North (which, depending on your location, may differ significantly from that shown by a magnetic compass) and tilted north from the horizontal through your local angle of latitude. This results in maximum output at noon around the time of the equinoxes (March and September), dropping to around 92% of that maximum at noon around the solstices (June and December).

For the southern mainland Australian states, this angle will be between 26° and 39°; for Tasmania, between 40° and 42°; and for mainland New Zealand, between 34° and 47°. 23° would be appropriate for locations such as Rockhampton or Alice Springs, which lie on the Tropic of Capricorn.

A case can be made for steepening the angle by a further 5-10°, which increases winter peak output to compensate somewhat for that season's increased cloud cover and shorter days. Unfortunately, this comes at the expense of summertime peak output and the longer summer days help very little as a fixed flat solar panel cannot be fully illuminated for more than 12 hours per day.

Tony Ellis,
Porirua, NZ.

Comment: thanks for the information. For the article, we obtained information from an Australian Government website which stated that tilt angle should be within 10° of the site's latitude, for at least 90% of optimum power generation.

For example, in Sydney, at 34° south, 24° tilt seems acceptable. As most roof pitches are 20-22°, installing panels flat onto a roof should be OK (if not exactly ideal) for the Sydney area.

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Mailbag: continued

Poor communication about MPEG-4 broadcasts

We received an information letter regarding digital TV six months before analog TV was shut down in our area. In this letter, there was no mention of MPEG-4, despite it being covered on the ACMA web page regarding digital TV.

Some TV manufacturers either do not (clearly) state what type of digital TV tuner is in their sets or receivers, or are unclear about the tuner type (eg, "depending on region" for DVB-T/DVB-T2).

So therefore, the following features should be the standard and not optional in all 4K TVs (and other receivers thereof): DVB-T2 reception capability on all tuners, decoding capability for H.265 video and the latest audio formats currently used (or which will be used) in broadcasting, Gigabit wired Ethernet (if networking functionality is included) and if wireless networking functionality is included, multi-stream Wireless-AC support.

All 4K TVs should have a minimum of four HDMI inputs, all supporting HDMI 2.0 and HDCP 2.2 along with feature support (eg, specific colour depth) which is identical among all HDMI inputs, with at least one HDMI input also having the ARC (Audio Return Channel) feature. Including all of these features should not cost that much extra, especially in mass production sets.

One of the biggest problems with digital TV is communication and poor communication can cause frustration and dissatisfaction among consumers.

Bryce Cherry,
Norman Gardens, Qld.

Think how much trouble VW got into for just writing code to bypass emission checks: fines of BILLONS of dollars and no one was directly injured or killed. A person who performed the interlock bypass would be deep in a brown, malodorous substance, and very deeply I would think.

While I still think any permutation of this idea is a Very Bad Idea, if you must do it, instead of taking the positive power direct from the battery, you need to ensure that the auto start relay is only supplied with power when all the inhibit systems are in a safe condition – gear lever in N or P as a minimum; some cars also require the foot brake and/or parking brake to be applied as well. Some manual vehicles also require the clutch pedal to be depressed as an additional safety feature.

I mean, really, you have to put your hand on the key to turn it from off to on, so how hard is it to turn the key to the crank position and release it when the engine starts? At least this way the engine only starts when you, the driver, WANT it to.

Richard Kidd,
Orange, NSW.

Comment: We messed up. It IS a very bad idea!

issues but despite this, the wiring instructions/diagram still bypasses all safety features provided by the inhibitor switch, leaving the vehicle as a potentially deadly trap for the unwary.

If people are stupid enough to microwave a microwave oven leakage detector (see warning on page 36 of the same issue), they are more than capable of killing someone by blindly following this diagram.

The legal implications if someone was injured or killed would be not nice, quite apart from the effect on the victim(s) and their families – or quite possibly your own family.

And the person who bypassed the interlock would probably be charged with criminal negligence and the insurance companies would run the other way when they discovered the cause of the accident.

In Australia we have Australian Design Rules. One rule says: if a vehicle is modified in contravention of ADRs, registration is invalid and insurance would consequently be void.

The vehicle would definitely not pass a registration inspection roadworthiness check in NSW if so modified; I'm not sure about other states but assume the same applies.

More discussion on loudspeaker linearity

I noticed the discussion in the February and March 2016 issues on the dynamic operation of loudspeakers. However, I note that voltage output from the amplifier is being used as the reference vector.

If I remember my electromagnetic theory, this should be "i". It is current that is directly and linearly propor-

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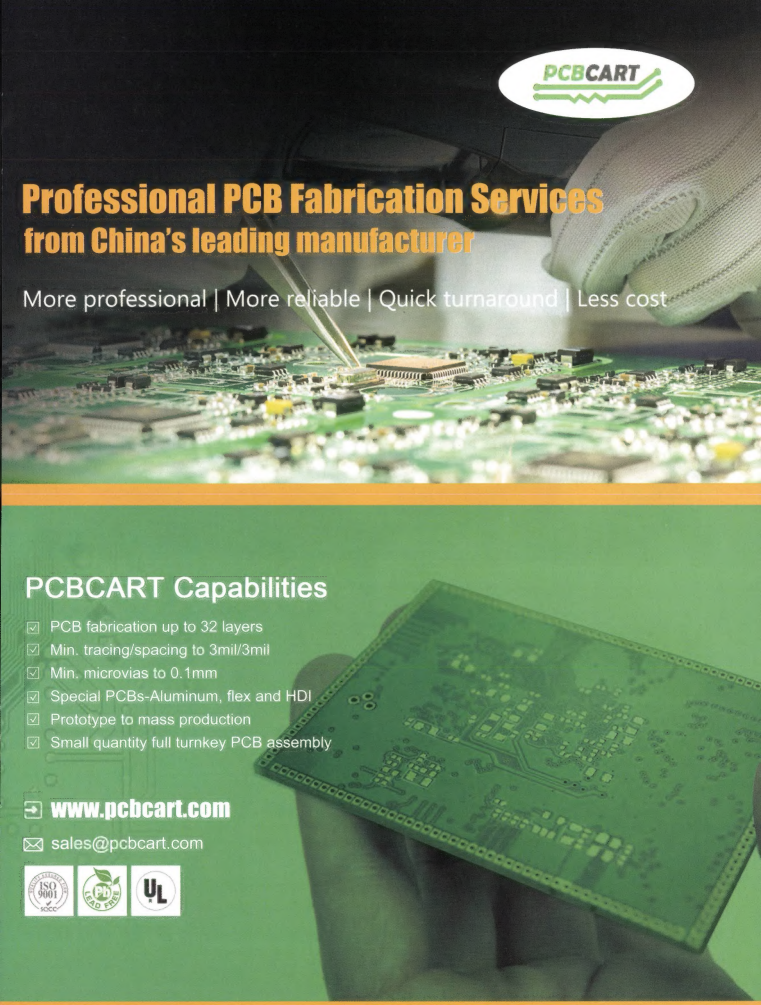
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Mailbag: continued

Electronics integration in cars still evolving

I have just read your March 2016 Publisher's Letter and I couldn't agree more with your observations about modern car electronics failing to integrate some obvious functions.

With a GPS in almost every car these days, why not have the speedo and odometer auto-corrected by GPS data for great accuracy? It would (or should) be straightforward to have the car's speedo/odo function derived from wheel rotation data but calibrated automatically now and then against GPS data, and this would ensure both continuity of speedo and odo reading during gaps in GPS coverage and near-GPS accuracy at all times.

John Tzerkeris (Mailbag, March 2016) commented on in-dash versus standalone GPS units and the longer manufacturing cycle. This may well be right, so why don't vehicle manufacturers partner with the experts in standalone GPS navigation units (eg, Garmin, Tom Tom and others) to get the best of both worlds? As for integrated cameras with SD card recording – bring it on; it's a no-brainer.

At the risk of contradicting myself, my 2012 Skoda wagon has attempted too much integration of electronics in a centre console touch-screen display: GPS, radio, media, phone, maps, navigation and settings. It's a Columbus unit with a sluggish touchscreen, awkward switching between functions and a user-hostile GPS with expensive map updates and old map data.

I have found to my frustration that, when navigating by GPS in heavy traffic in unfamiliar territory, if I change screens to adjust a radio setting then the GPS stops navigation guidance without warning but still shows me the moving map anyway, a cunning trap to be discovered only later when I miss a turn I should have taken but didn't as the GPS navigation guidance had gone to sleep.

This is an excellent example of how not to integrate a lot of vehicle functions and should be used as a learning opportunity by automotive electronics designers. There have been a few times, always in challenging and stressful situations, when I have wanted to rip it out and throw it out the window as the Publisher did (Publisher's Letter, November 2015) but fortunately I had to keep driving and let my blood pressure slowly go back to normal as I unravelled the navigational pickle it had got me into.

Graham Carter,
Ainslie, ACT.

tional to mechanical deflection of the voice coil. The historic aim in audio technology has been to build amplifiers whose output voltage precisely follows the input signal.

Whilst a quality amplifier delivers a perfect output voltage, the current delivered is determined by the load impedance and only into a resistive load will the current be directly proportional to the voltage. Having gone to the trouble of producing an ideal voltage amplifier, we promptly load the output with a highly inductive linear electric motor, the purpose of which is to directly drive an air pump to disturb the air with all manner of complex patterns which would drive even Fourier to distraction.

Not only do we have the pure inductive component, there are further reactive effects and back-EMF caused by air loading and the energy stored in spring components of the speaker, not to mention cabinet loading and electromechanical resonance effects.

Essentially, a speaker designer attempts to produce an inductive device which behaves like a resistor or at least pushes air in proportion to the driving voltage, even though it is current that should be in exact proportion to the input of the amplifier. This problem is also similar to a tape recorder's inductive recording head where the flux across the head gap is the product of current and voltage.

This problem was solved in high-performance recorders in one of two ways (or a combination of both): (1)

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Mailbag: continued

Soldering SMD parts with a stencil is easy

I read the letter from Barrie Davis in the March 2016 issue. I would like to say that SMD construction makes it easier to solder. All my new designs try to maximise the use of SMD for hand assembly. It's faster and easier to populate an SMD board by hand than the equivalent through-hole design.

First, you must have a professionally-made PCB with solder mask. Don't attempt the following procedure with a home-etched PCB. The solder mask means that solder and components will only stick where they are supposed to and minor alignment issues are eliminated.

If your unsteady hands can put down a resistor so that it is touching one corner of its correct pads, then the surface tension of molten solder will draw it onto the pad automatically. Big ICs with leads 0.5mm apart will align themselves. Bumping adjacent components is the real problem – design big gaps between the tiny components.

The second contributor to speed and accuracy is the solder stencil. Once again, use a commercial service which will produce a stencil to match your boards at a buck or two per square inch. Once it's placed on top of the PCB and aligned properly (normally done using pins), one quick swipe with solder paste puts exactly the right amount onto every pad.

Solder paste is currently a speciality item and is likely to stay that way as it has extremely fine solder particles (toxic lead, unless you choose lead-free) and it dries out in a few months unless stored in the freezer. If you don't get the stencil exactly right, the solder mask helps draw the solder onto the pads and errors magically fix themselves during reflow.

Once the PCB is stencilled and all SMD components placed, I heat it in a fry-pan on the stove until all the solder goes shiny. I originally used an IR thermometer but now I know what setting on the stove to use, I don't bother. The "toaster oven" method is also popular and inexpensive. A nearly unlimited number of components can be soldered in two minutes this way.

The drawback to this method is it only works on an entire board at once. Desoldering and replacing one component still requires steady hands.

Morgan Sandercock,
Oregon, USA.

by increasing the output voltage signal enough to allow a resistor to be added in series with the record head, sufficient to swamp the reactance of the head (this makes the current flowing through the head predominately proportional to the voltage); and (2) inserting the head in the overall feedback loop. Record head power needs are only in the fractions of a watt but I would think the same principles could be applied to power amplifiers, both valve and solid state. Even if only partially applied, it would alleviate some of the design problems associated with speakers.

Kelvin Jones,
Kingston, Tas.

Comment: it is true that the current delivered to a loudspeaker system is a function of the amplifier driving voltage divided by the loudspeaker's impedance, which is anything but purely resistive.

However, loudspeakers are designed on the assumption that they will be driven by a pure voltage source. On that assumption, the loudspeaker is supposed to deliver a flat frequency response. As you say, "Essentially, a speaker designer attempts to produce an inductive device which behaves like a resistor or at least pushes air in proportion to the driving voltage . . ."

It is also assumed by the designer (if he or she thinks about it at all) that the amplifier will be able to handle any large variations that may occur in the loudspeaker system's impedance over the full audio bandwidth. Some amplifiers may perform quite badly with the extreme variations in impedance of some loudspeakers, particularly if the impedance dips to very low values, say only a couple of ohms. That may cause amplifier overload with some music signals. Or some loudspeaker systems may even cause the driving amplifier to be supersonically unstable.

Your premise seems to be that the amplifier should be a current source, as in tape head drive stages. That is quite wrong and unlikely to give good results with any loudspeaker, especially 2-way or 3-way systems which incorporate a passive crossover network that is designed to be driven with a voltage source.

Continued disagreement on loudspeaker operation

Thanks for publishing my email in the Mailbag pages of the April 2016 issue. Unfortunately, I feel that the Editor's comments further mischaracterise the behaviour of components in an audio amplifier/speaker arrangement. After reading those comments, it occurred to me that we were talking about damping in different senses.

There are two senses in which "damping" could be used: it can describe a component's or a material's propensity to dissipate energy (by virtue of its resistive nature), or it could describe the way the impedance of a component or material suppresses voltage, current, force or velocity without necessarily dissipating energy.

Unfortunately, while the former has some rigorous technical description and currency, the latter has much less. I was (for the most part) using the former concept of "damping", while I think the Editor was mostly using the latter, although in the comments he seems to use it in both senses.

It is certainly true that the output impedance of an amplifier will suppress any voltage generated by motion of the speaker diaphragm that appears at the amplifier's output terminals; it just turns out that this has virtually no damping effect (in either sense) on the diaphragm because of the voice coil impedance (plus cable and crossover network impedances to a lesser extent). Damping of the diaphragm is accomplished almost entirely by the mechanical system; the electric circuitry has virtually no effect.

That is not to say that amplifier output impedance is irrelevant to good performance. It is the parameter that describes how well the amplifier can determine the voltage at the loudspeaker terminals regardless of variations in speaker impedance. This is vital for maintaining a flat frequency response.

You are correct that as sound propagates through air some energy is lost, but very little in this scenario. The most significant property of the mass of air trapped in a loudspeaker enclosure is its compliance, and mechanical impedance is related to compliance by the same equation that relates the electrical impedance of a capacitor to its capacitance (http://en.wikipedia.org/wiki/Impedance_analogy#Capacitance).

The impedance of the mass of air behind the loudspeaker is predominantly reactive; it behaves like a spring, ie, it dissipates little energy.

While the air behind the loudspeaker works against the motion of the diaphragm, it damps the motion in the second sense, not by dissipating energy. If this were not the case you might try to explain why changing the volume (and hence the mass) of air inside the cabinet of a sealed system shifts the resonant frequency. If it merely increased the losses there should be no shift in frequency. Certainly the Q of the system changes too, but this is because the resonant frequency has shifted.

Consider that in a parallel LRC circuit, Q is given by Q = 2πf/C (f is the resonant frequency), so if you increase C, Q goes down. This is not an exact analog of a loudspeaker system; I am merely trying to demonstrate that retuning a resonant system can affect damping factor. In effect, smaller volume reduces compliance (increases stiffness), which is analogous to reducing capacitance in an electrical circuit.

Phil Denniss,
Darlington, NSW.

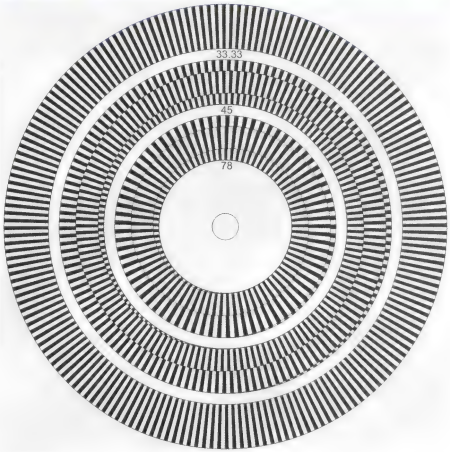
Improved turntable strobe disc

John Clarke's design for a stroboscopic light source in the December 2015 issue drew my immediate attention. I too have noted that the rather weak 100Hz "flicker" component of modern compact fluorescent and LED lighting systems makes it difficult to use a stroboscope to check turntable speed.

Having an interest in very early sound recordings, a means of checking playback speed is a basic requirement, especially when using a continually variable speed turntable with an uncalibrated speed control. A cold 100Hz light source with an optimised mark/space ratio as described in last December's SILICON CHIP should be almost ideal. I write "almost" because with due respect, I feel the design suffers somewhat from overkill.

For starters, I would consider the normal mains frequency tolerance to be accurate enough for even the most fastidious listener. It would be surprising to find anyone, even those rare individuals blessed or cursed with absolute pitch, who would be aware that a turntable was running (at most) 0.3% fast or slow.

As testimony to this fact, I cite the countless millions of viewers (including musicians), who were unaware that, whenever they watched a PAL TV broadcast or VHS tape



of a feature movie, it was running at 25 frames per second instead of the intended 24. This amounts to a 4% increase or roughly 13 times normal mains frequency tolerance. Admittedly, this 4% pitch and speed increase was often disturbing to the gifted few with perfect pitch but for the overwhelming majority, it went completely unnoticed.

Returning to the December strobe light design, I see absolutely no need for the optional 120Hz flash rate. The reasons given for this feature totally lack any validity, even assuming that the supposed errors were enough to cause concern.

For starters, a record speed of 78 RPM has never officially existed. From about 1913 to 1925, most recording turntables rotated at a de-facto standard of 80 RPM, following the example of Edison who had merely halved the standard cylinder record speed of 160 for his unique "Diamond Disc" records. Prior to this, discs played at anything from 70-95 RPM. (French Pathe even released a line of 20-inch discs that spun at 120 RPM)!

With the advent of electrical recording/playback, competing record companies agreed that a formalised standard speed should be agreed upon. But at no time was this exactly 78RPM. Instead, the record industry ended up with two minutely different speeds. In countries like Australia and Great Britain, with a mains frequency of 50Hz, discs were recorded at exactly 77.92 RPM. In those countries with 60Hz mains, the speed was standardised at 78.26 RPM.

It is hardly surprising that, for everyday use, these minor speed discrepancies were ignored and records released from either side of the Atlantic (or indeed, anywhere in the world) had labels proclaiming the rounded off speed of "78 RPM".

Nevertheless, this meant that discs recorded and played in 60Hz countries were rotating at their precisely correct speed when using a 92-bar stroboscope; ditto for 50Hz countries using 77 bars. Admittedly there was a theoretical error whenever a UK recording was played in the USA or vice versa, but in practice this was purely academic. I doubt that anyone was ever aware of this error (approximately 0.1%), again keeping in mind that a 4% speed increase passes unnoticed by most listeners.

This leaves us with 45 RPM as the

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Mailbag: continued

Comment on HMV model 209/66 radio

I have just read through Graham Parslow's excellent article on the renovation of a HMV model 209/660 radio in the March 2016 edition.

He says "... the 0.5µF AVC (AGC) bypass capacitor (C11) was hot. Replacing this immediately reduced power consumption to 82W...". Shorting out the AVC capacitor should have negligible effect on the power consumption. C11 is in fact the B+ bypass capacitor and any significant leakage here will have the effect of placing the field coil directly across the rectifier output, hence the 25% rise in consumption.

This demonstrates the benefit of monitoring the power consumption, however a circuit voltage check and a finger test on the caps (after removing the power) would also show this up. Also, simply not leaving "old" caps in positions subject to high voltage would have avoided this.

Geoff Trengove, Maryborough, Vic.

Graham Parslow comments: Geoff is absolutely correct and he has explained something that did not make sense to me at the time. I misread the circuit diagram and did not deduce the true reason for the heating of the capacitor. I was puzzled as to why a capacitor in a low current section should heat up so much. Now all is clear.

only speed that seemingly requires a 120Hz light source in order to be "spot on". After all, we are informed that "... it is not possible to obtain a correct pattern for 45RPM at 50Hz". Sorry, wrong again!

When I read this statement in the December article my thoughts went back to a letter that was published in *Electronics Australia* back in April 1985. The writer was a Melbourne-based computer programmer named David Yee who revealed that he had successfully devised a system that enabled him to print out 100% accurate strobe discs for any desired turntable speed or lamp supply frequency. As proof, he submitted a photo of such a disc that would exactly indicate speeds of 33⅓, 45 and 78RPM when illuminated by a lamp running off 50Hz AC.

Shortly after reading his article, I took advantage of Mr Yee's offer to supply precision strobes for any combination of lamp frequency and turntable speed. For reasons of space (I won't go into why), I needed to accurately set a variable speed turntable to 22½, 39 or 47½ RPM. In very short time, a customised strobe arrived that performed exactly as I had requested.

Fast-forward 30 years and I again

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managed to contact David Yee. Was he still able to provide his unique strobe discs? David promptly emailed back to report that, due to compatibility problems between current PCs and his 1984 program, this was no longer possible.

However, the good news is that a mere two days later another email arrived reporting that he had re-written the program and was again able to supply his 100% accurate strobe discs. He had even added a bit of "cosmetic enhancement" to the style of his original design and attached a sample. The result is the precision 3-speed 50Hz stroboscope reproduced here (page 12), all ready to photocopy and use under any light source with a high 100Hz flicker component (this even includes tungsten filament bulbs, preferably under 60W).

David Yee has kindly given me full permission to submit this image of his stroboscope to SILICON CHIP for possible publication. What is more, he wishes it known that, should any readers have need of a stroboscope for any other turntable speed they need only to email him at deeyee@hotmail.com

In spite of my reservations concerning Mr Clarke's turntable strobe project, I'll probably end up building one but minus that 120Hz flash rate option.

Charles Slater,
Bowral, NSW.

Comment: the specific reason why we provided the 120Hz option is so that the strobe could be used with any turntable that has strobe markings on the platter or on the periphery (many do). That way, you can set an exact 45 RPM speed with a stationary pattern. That is not possible if you are using such a turntable under an exact 50Hz light source.

Having said that, Mr Yee's spiral strobe pattern is indeed a clever solution if your light source is 50Hz (or 100Hz).

Solar system installation & repair experience

I had a solar system installed by Origin Energy about four years ago and having read many of the previous letters of concern in SILICON CHIP, I wish to share my experience. Within a week of our system being installed, the installer returned and added another isolation switch in parallel to the original situated just below the inverter.

The system has worked well for us during the summer months, building up credit even while running our split-system air-conditioner. Then, during winter, we consume that credit running the air-conditioner in reverse cycle mode for heating, leaving a very small balance to pay.

I did some research when it was installed. We had 11 panels totalling 2100W. The open-circuit voltage was 497.5V at 5.6A. Interestingly, the two switches (installed in parallel) were only rated at 500V. I have never seen the inverter show it was producing anything over 1800W.

In November, we had the split-system air-con replaced with a ducted reverse cycle system. The day after this, I was looking at what the installers had done and noticed my inverter was showing a relay fault error. Doing some sums, I realised it had not been working for some time and the failure was not related to the installation.

Looking up the model and error code on the internet, I found it was a common fault. Imagine my surprise when it was all fixed within four days. The electrician turned up with another four inverters in his van that were for replacements. He checked my inverter, confirmed the error code and said it needed to be replaced but he was not happy that the isolation switches were installed under the inverter. This could allow water to run down the conduit and into the switches.

I was advised when placing the service call that the inverter was under warranty but any repairs due to water in switches was chargeable. I decided to accept this and debate it later if need be. After all, they installed them there.

I asked about the voltage rating of the switches. He made a phone call, got out his iPad and proceeded to take several photos of the switches and several more on the roof. There was only one isolation switch up by the panels. He wasn't happy with that either. My panel frames were earthed but the rails holding them were not.

Several hours later, he had removed and replaced all panels and earthed each panel again, including the rails. He also fitted a 1200V-rated isolation switch by the panels, another alongside the inverter and re-did the wiring from the inverter to the fuse box.

Now the system can actually produce over 2100W. Thankfully all the repairs were covered under the warranty. Origin even rang me two days later to make sure I was happy with their service. I told them I was.

Geoffrey Hansen,
Littlehampton, SA. SC

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Atmospheric Electricity:

By
DR DAVID MADDISON

NATURE'S SPECTACULAR FIREWORKS!

If you think about nature's electrical fireworks, lightning and the auroras at the poles immediately come to mind. But now we can see that what happens out in space is vastly more spectacular and in fact, much larger than planet Earth. This is the story of Nature's planet-wide spectacle which has been running ever since the Earth was formed.

Earth's atmosphere is highly electrically active, most visibly manifested by phenomena such as spectacular lightning displays and, for those living in the higher latitudes, the Aurora Australis and Aurora Borealis.

Then we have the invisible ionosphere, which plays a vital role in the propagation of radio signals for long distances.

Other electrical and related phenomena in the atmosphere and near space include the magnetosphere, coronal mass ejections from the Sun impacting the magnetosphere, the solar wind, the plasmosphere, the ring current, the Van Allen Belts, electrical charging of clouds and transient luminous events such as sprites, elves and blue jets. Plus there are controversial unexplained phenomena such as ball lightning.

History

Early experimenters noticed the similarity between sparks and discharges from electrical machines, Leyden jars and lightning, and concluded that they were the same phenomena.

It was William Wall in 1708 that first noted that spark discharges resembled miniature forms of lightning. In 1750 Benjamin Franklin thought that electrical charge could be drawn from clouds with a tall enough metal aerial but he was beaten to the experiment in 1752 by Frenchman Thomas-François Dalibard who managed to draw sparks from a passing cloud with a 12m aerial.

In 1752 Franklin is said to have performed his famous kite experiment (however, there is some dispute now as to whether Franklin ever did that experiment!). It *was* done by Romas and Cavallo, both of whom drew long sparks from a metal string.

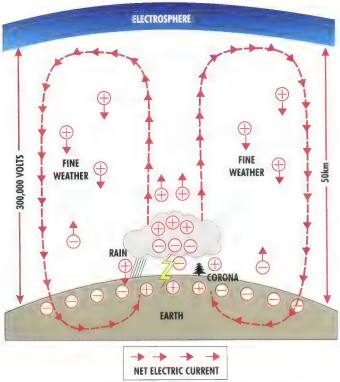
G. Beccaria repeated Le Monnier's work and determined that the atmosphere had a positive charge. Other later workers found seasonal variations in the Earth's electric field and variations with altitude.

L.G. Le Monnier was another that repeated the kite experiment and discovered the electrical field within the atmosphere which came to be known as the "fair weather condition".

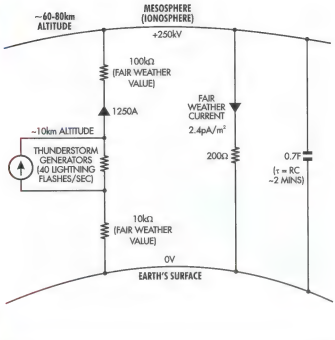
Vertical electric field in the atmosphere

There is a high strength vertical electric field in the atmosphere. On a clear day, over flat land or the ocean at the equator, this is around 120V/m so there might be a potential difference almost 200V between your nose and the ground.

We do not notice this because the body is a relatively good conductor and so the potential difference is "shorted out", bringing the potential between your nose and the Earth close to zero.



Atmospheric electrical circuit showing the relationship between fair weather current flow and charge transport in thunderstorm conditions.



Electrical equivalent circuit of atmospheric electrical flow with thunderstorms. Note that some values are slightly different to those mentioned in text as different values are used by different researchers. (After www.slac.stanford.edu/cgi-wrap/getdoc/slac-wp-020-ch11g-Kirkby.pdf)

The field is in a direction that gives the surface of the Earth a negative charge under normal circumstances, the "fair weather condition".

The electric field continues to increase with height (although not in a linear fashion) until an altitude of around 50,000 metres (that's more than three times higher than jet aircraft fly), at which point the atmosphere is sufficiently conductive, due mainly to ionisation by ultraviolet light, that no further increase in potential occurs.

The potential difference between that altitude and Earth has a mean value of 280kV, varying from 150kV to 600kV.

Even though the electric field gradient extends to 50km altitude, most of the charge is located within the first 10,000 metres, since the net positive charge contained between the ground and 10,000 metres is nearly equal to the net negative charge of the Earth. At 10,000 metres, the electric field gradient has reduced from around 120V/m to around 5V/m.

One might ask the question, "Why not use this potential difference to generate power?"

It has been asked many times before! But since air is a good insulator, the current available is very small, so little useful power could be generated.

Although it is possible to use this field to drive a small electrostatic motor you can build yourself (see box), little useful work can be done. In fact, the current density of the atmosphere is around 1pA (picoamp) per square meter in built-up areas, to 2.4pA per square meter in most other areas.

An often-cited figure for the total current over the whole of the Earth's surface is around 1800A; the range is 750 to 2000A.

Using typical figures of 1800A total current and 280kV mean potential, the total power for the entire Earth is 504 megawatts. Using the voltage and current figures in Ohm's Law also allows us to calculate the effective resistance of the atmosphere as 155Ω.

The air of the atmosphere is generally regarded as a good insulator unless it is heavily ionised, as is the ionosphere, in which case it becomes an electrical conductor.

The fact that some small current does exist from the atmosphere to the Earth does mean that the atmosphere is somewhat conductive. The main source of the lower atmosphere's limited electrical conductivity is ions which are air molecules which have either gained or lost an electron and are no longer electrically neutral and therefore able to carry charge.

How are the ions generated?

In 1912 Hess, with a balloon-borne electrometer, established that the amount of ionisation of the air increased with height, meaning that whatever was causing it was stronger at high altitudes. This was a mystery because it was previously thought that ground-based radioactivity was causing electrons to be stripped from atoms and molecules, turning them into ions.

It was eventually proved that cosmic rays from outer space were responsible for the generation of a majority of atmospheric ions, constantly replenishing them as older ions are carried to Earth in the charge transfer process. Apart from ions, charge can also be carried on dust and water droplets. Ions can also be generated by radioactivity at ground level but that is not the major contributor to ions in the atmosphere as originally thought.

Interestingly, the potential gradient of 120V/m at the equator increases to 300-400V/m in industrial areas with a lot of dust. (The figure is typically 155V/m at 60° lati-

tude and 71V/m at the South Pole, although these figures do vary with time).

How does the Earth become charged?

How is this charge maintained? If it were not replenished there would soon be no charge on the Earth. It is estimated that the negative charge of the Earth would dissipate in 10 -60 minutes, so how the charge was replenished remained a great mystery in the early days of research into atmospheric electricity.

It is now known that thunderstorms, lightning and electrified (but non-thunder) clouds are the "battery" responsible for maintaining a permanent potential difference between the upper atmosphere and the surface. Bolts of lightning do not discharge the entire atmosphere as might be thought but a majority of lightning strikes bring a large amount of negative charge to Earth's surface. The corresponding return part of this circuit occurs elsewhere, in areas of fine weather.

As mentioned above, the Earth has a net negative charge and the electric field is directed downward. Current flows from sky to Earth in areas of good weather. Beneath thunderstorms however, a positive charge builds up on the Earth's surface. In that case the field is directed upwards and current flows from the Earth to the sky.

The two areas of flow together complete an electrical circuit which keeps the charge on the Earth replenished as illustrated in the diagram. At any given time about 1% of the Earth's surface that is beneath thunderstorms carries a positive rather than negative charge.

All around the world, 24 hours a day, there are around 40 to 50 lightning flashes per second so there is certainly enough activity to keep the Earth-atmosphere system charged.

What causes lightning?

Lightning is an extremely complex process, even today not fully understood.

Essentially what happens within a thundercloud is that due to convection currents, lots of ice particles and water droplets rub across each other, causing them to become charged. This is similar to what happens when you rub two insulating items together such as wool and a balloon.

Pure ice crystals develop a positive charge while "graupel", a water and ice mixture with a slushy consistency, becomes negatively charged. The lighter ice crystals are carried by updrafts in the cloud while the heavier graupel stays near the cloud base. This results in charge separation within the cloud, with positive charge near the top and negative charge near the bottom.

The positive charge at the top of the cloud and the negative charge at the bottom of the cloud form a "battery" that is of the correct sign to drive the Earth beneath it negative. Typically the positive charges are 6 to 7km high at a temperature of around -20°C and the negative charges are 3 to 4km high with a temperature of around -10°C.

This charge builds and builds – and when a sufficient charge has developed between oppositely charged areas such as between a cloud and Earth, within a cloud or between clouds, the normally insulating air breaks down and becomes conducting.

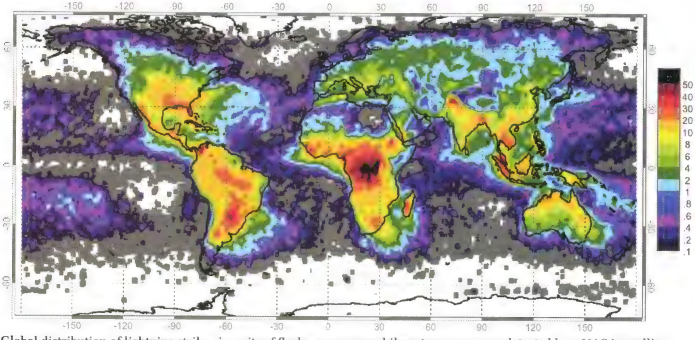
The exact processes are complex and not well understood but for a cloud-to-ground strike the process is as follows:

1) A downward "leader" is formed and descends from the cloud.

2) When the leader approaches the ground an upward streamer can form which is much like a leader but in the opposite direction.

3) "Attachment" occurs where the leader and streamer connect, establishing a low-resistance electrical pathway.

4) "Discharge" or the "return stroke" occurs which is the most powerful part of the lightning strike, resulting a discharge of energy from the cloud to the ground with a typical current of 30,000A and up to several hundred million



Global distribution of lightning strikes in units of flashes per square kilometre per year as detected by a NASA satellite carrying the Optical Transient Detector (OTD) and the Lightning Imaging Sensor (LIS). The place that receives the most lightning is near a village in the Democratic Republic of the Congo with around 160 strikes per square km per year.

volts. A number of return strokes can happen in quick succession and the return stoke neutralises the positive ground charge caused by the storm. You can see a video of these phenomena at http://you.tube/dukk07c2eUE

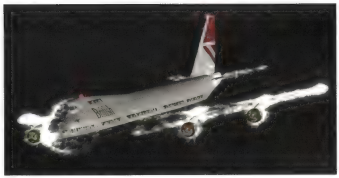
A conventional cloud-to-ground to discharge is called a negative stroke but there are rare positive strokes as well, which originate at the tops of clouds and are much more powerful. While aircraft are designed to withstand negative strokes, positive strokes were unknown when aircraft lightning safety standards were first established and it is unclear how well they would withstand a hit with such a lightning strike (see www.damninteresting.com/the-power-of-positive-lightning/ for a report on the first aircraft known to have been destroyed by positive lightning).

There are several different types of lightning. Some variations include "superbolts" which are about one hundred times more powerful than normal lightning and "ball lightning", the actual existence of which is unproven but subject to intense speculation.

Ball lightning is in the form of luminous free floating spherical objects up to a metre in size, is usually associated with cloud to ground discharges, lasts from a second to a minute, often moves horizontally and has been claimed to go through solid objects and has even been claimed to appear inside an aircraft cabin.

St Elmo's Fire is a coronal discharge that can occur in areas of high electric field such as might appear beneath thunderstorms. Throughout history, it has occurred as an eerie glow on the spars of sailing ships – a portent of doom according to sailors.

An effect similar to St Elmo's Fire was the glow which surrounded flight BA9 after it flew through a cloud of volcanic ash over Indonesia on 24 June 1982, nearly causing the plane to crash (https://en.wikipedia.org/wiki/British_Airways_Flight_9)



An eerie glow, visible from inside the plane, occurred when a British Airways flight passed through the ash of an erupting volcano. At the time, all four engines had failed.

The global electric circuit

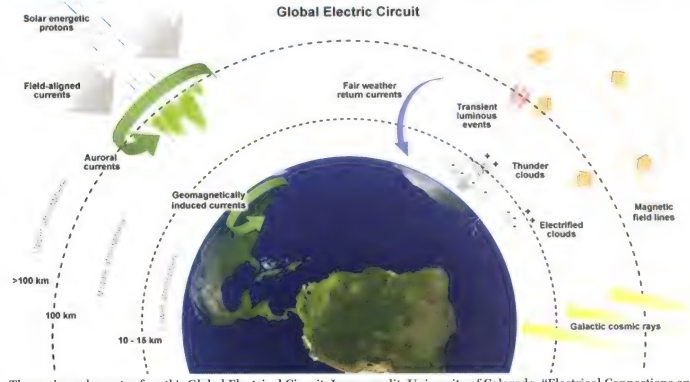
The continuous electric current between the lower layers of the ionosphere and the Earth's surface is known as the global electrical circuit (GEC).

In recent times it has come to be understood that this system is vast, extremely complicated and variable and has many factors that influence it.

The Sun has a major influence on the GEC and atmospheric electrical phenomena. Apart from bathing the world in life-giving energy, the Sun emits a constant stream of charged particles which hit the Earth's protective magnetosphere. These eventually pass down magnetic field lines which are concentrated at the magnetic poles where they cause the Aurora Borealis in the northern hemisphere and the Aurora Australis in the southern hemisphere.

The aurora has associated large electrical currents or "electrojets" flowing in the direction from the day side to the night side.

Occasional explosions of huge amounts of material from



The various elements of earth's Global Electrical Circuit. Image credit: University of Colorado, "Electrical Connections and Consequences Within the Earth System" (ECCWES) project.

Nikola Tesla

Despite the claims of many conspiracy theorists (and, we must warn, modern-day internet scams), Nikola Tesla did not invent a method for harvesting large amounts of "free energy" from the atmosphere.

He did however have a lot of interest in wireless transmission of electrical energy and radio, something that is firmly based in science.

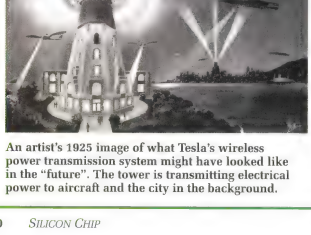
In 1900, Tesla had asked J.P. Morgan to invest in his Wardenclyffe tower project to transmit a wireless radio signal across the Atlantic Ocean. Morgan agreed to this and funded the project to the extent of US$150,000. Telsa had also planned experiments in wireless power transmission but did not initially tell Morgan about this.

On the 12th December 1901, Marconi managed to send radio signals across the Atlantic thus beating Tesla to this goal as Tesla's project was still under construction. In 1903, Telsa finally revealed his intention to Morgan of wireless power transmission and Morgan declined further funding.

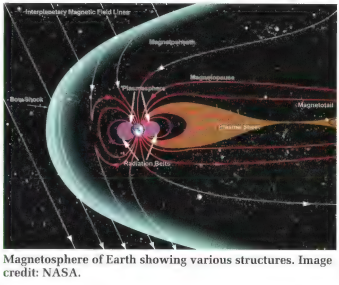
Conspiracy theorists claim this was because Morgan saw that wireless power transmission could not be metered but the reason is that Morgan did not find the idea attractive and also he had already told Tesla he would not invest more than the originally agreed amount. In addition, Tesla's radio system was more expensive than Marconi's. Further, the "Rich Man's Panic" of 1903 made it difficult for Tesla to get funding from others and also his own patents for his previous inventions expired, leading to very difficult times for Tesla.

A detailed rebuttal of the conspiracy theorists' claims can be found at http://thelibertarianrepublic.com/evil-capitalists-prevent-nikola-tesla-creating-free-energy/ See also https://en.wikipedia.org/wiki/World_Wireless_System

It turns out that short range wireless power transmission is coming into use for applications such as charging mobile phones but even medium and long range wireless power transmission is possible. Techniques involve inductive, capacitive and magneto-dynamic coupling and microwaves or lasers.



An artist's 1925 image of what Tesla's wireless power transmission system might have looked like in the "future". The tower is transmitting electrical power to aircraft and the city in the background.



Magnetosphere of Earth showing various structures. Image credit: NASA.

the Sun occur during events known as coronal mass ejections that can impact the Earth causing disruption of communications and electrical grids and damage to satellites. These events can also lead to spectacular aurorae, often extending much further toward the equator than normal.

The Sun is responsible for providing most of the radiation that ionises the ionosphere and the properties of the ionosphere vary with the 11-year sunspot cycle.

The Magnetosphere

The magnetosphere is a region around Earth with a magnetic field in which charged particles from the Sun (or elsewhere in space) are influenced by the field.

Near the Earth, the field is shaped much like that of a bar magnet but further away it is greatly distorted by the continual flow of particles from the Sun, the solar wind.

The magnetosphere protects the Earth from harmful charged particles by deflecting them around the Earth or into the polar regions. Without the magnetosphere, life would be very challenging or it may not even have evolved at all.

The solar wind would also eventually strip away much of the atmosphere, as is believed to have happened on Mars (which has neither a protective magnetic field nor significant atmosphere – it's less than 1% of Earth's and is 95% carbon dioxide).

There are a number of structures within the magnetosphere. The first one is the *bow shock* which is the leading edge of the magnetosphere that particles first encounter, setting up a shock wave as they are moving at around 400km/s.

The *magnetopause* is an area of balance between the planet's magnetic field and the solar wind.

The *magnetosheath* is a magnetically turbulent region between the bow shock and the magnetopause. The particles in this region are mainly solar wind from the bow shock.

The *magnetotail* is the opposite structure to that of the compressed magnetic field on the side of the Earth facing the Sun. It extends far out into space and between the upper and lower structures there is a sheet of plasma.

The *plasmasphere* is located above the ionosphere and is also known as the inner magnetosphere. It contains low energy or cool plasma. It was discovered due to the analysis of VLF Whistler data, which will be discussed later in this article.

Van Allen radiation belts

Within the inner part of the magnetosphere exist the two Van Allen radiation belts, discovered in 1958. These trap energetic charged particles within the magnetic field and can cause damage to spacecraft if those are not protected.

The Atmosphere

Earth's atmosphere is the medium in which an electrical gradient and associated current is maintained and also the medium in which thunderstorms develop, thus forming a vital part of the global electrical circuit.

Ionosphere

The ionosphere exists as a layer from about 65km altitude to about 600km. One of its most important properties is that it reflects radio waves. It can do this because it contains a significant proportion of charged particles in the form of atmospheric atoms which have had electrons removed by high energy radiation from the Sun, such as UV and X-rays as well as, to a lesser extent, cosmic rays from space.

These particles are said to be "ionised", hence the name of this layer. These particles form a plasma that is electrically conductive and hence capable of reflecting radio waves under the right circumstances and conducting electrical currents. The properties of the ionosphere vary from day to night and also according to geomagnetic activity such as solar outbursts.

For further information about the ionosphere see the article on HAARP, SILICON CHIP, October 2012.

Cosmic Rays

Cosmic rays generate most of the ions which are the current carriers for the atmospheric electrical current. These are mostly atomic nuclei originating from somewhere out in space which strike the Earth's atmosphere at near-light speeds.

Geomagnetically induced currents

Geomagnetically induced currents are currents induced into artificial electrical conductors (such as long power lines or telephone lines) on Earth, as a result of electric fields produced by rapid magnetic field variation during geomagnetic storms. These currents can cause damage or destruction of transformers and can even bring down entire electrical grids. Electrical grids are much more vulnerable when they are heavily loaded with little excess capacity.

A severe geomagnetic storm, which struck the Earth on 13 March 1989, brought down Canada's Hydro-Quebec 735kV power grid; the blackout lasted nine hours and was ended only when the utility company implemented many temporary bypasses and "fixes".

Schumann resonance

The area between the Earth and the densest, most conducting part of the ionosphere forms a wave-guide that has a certain resonant frequency and conducts electromagnetic waves that are generated by lightning discharges around the planet.

It was named after physicist Winfried Otto Schumann who in 1952 predicted that this cavity between the Earth and ionosphere would have a characteristic resonant frequency.

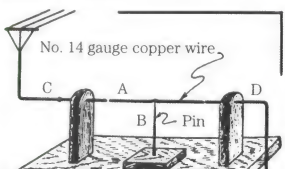
The fundamental Schumann resonant frequency is 7.83Hz, with peaks at intervals of around 6.5Hz: 14.3, 20.8, 27.3 and 33.8Hz.

A "Static Motor" from the 1920s

Static Motor

Here is a contrivance which will amuse and interest the young electrician. It consists of a small piece of number fourteen gauge copper wire (A), balanced on a pivot (B). Two wires (C) and (D) are supported so that their ends are very close to the ends of wire (A). Connect the lead-in from an aerial to one of these wires, the ground wire to the other, and if everything has been properly made, and if there is a sufficient charge of static on the aerial, the movable wire (A), or armature, will commence to revolve.

For best results (A) should be about $1\frac{1}{2}$ inches long, the distances between the ends of the stationary wires and the ends of (A) being about one thirty-second of an inch. Contributed by S.C.W.



A static motor operated from the ether waves collected by an aerial.

11-4 Atmospheric electric motor. *Practical Electrics*, 1924

The video "Free Atmospheric Electricity Powers Small Motor – Tesla Radiant Energy" (https://youtu.be/do4IO_U3B5o) shows the operation of a small motor powered by the electric field gradient in the atmosphere. A hexacopter was used to hoist the antenna wire around 30 metres into the air. The video title implies a connection with Nikola Tesla's ideas. Tesla never proposed harvesting "free energy" but did have ideas of wirelessly transmitting electrical energy. This screen grab from that video comes from the book "Homemade Lightning: Creative Experiments in Electricity" 3rd Edition but originally comes from the publication "Practical Electrics" from 1924.

Listening to the sounds of the ionosphere. . .

It is relatively easy to hear natural signals from the ionosphere and elsewhere, "Earth songs", such as from lightning, tweeks, whistlers, the auroral chorus, hisses and other sounds, although they won't happen all the time so patience will be required.

One way to listen to to these signals is to connect via the internet to a number of VLF receivers that are on-line at all times. One site with links to a number of these receivers is at http://abelian.org/vlf/ The received signal at Florida seems particularly active. Many people find these sounds quite relaxing to listen to and they may even help you go to sleep!

A selection of WR-3 receivers (row at bottom) being field tested at a radio quiet location in California before shipping to customers. The author owns one of these units.

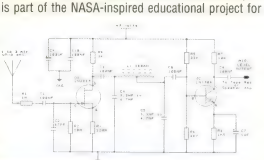
Live streaming of a VLF signal can also be heard at www.vlf.it/cumiana/livedata.html along with a number of regularly updated spectrograms representing the outputs of different VLF station setups.

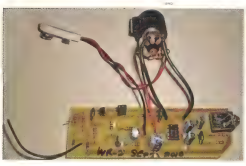
Another method to listen to Earth songs is to purchase a broadband VLF receiver such as the fully assembled WR-3 receiver from www.auroralchorus.com/wr3order.htm These are made as a cottage industry by pioneering hobbyist Stephen P. McGreevy rather than a commercial organisation. Examples of auroral recordings made by Stephen McGreevy can be heard at links on www.auroralchorus.com/aucho.htm The device sells for US$170, including shipping to Australia. The WR-3 is also available without a housing or antenna and costs US$85 shipped to Australia. The user needs to supply appropriate standard headphones in both cases.

Stephen McGreevy also has free plans for his BBB-4 "bare bones basic" receiver at www.auroralchorus.com/bbb4rx3.htm

A different VLF receiver is available in kit form, called the Inspire VLF-3. This is part of the NASA-inspired educational project for natural VLF signals. An Inspire VLF-3 kit costs US$155, including shipping to Australia. The order page is at http://theinspire-project.org/default.asp?contentID=27

The circuit of Stephen McGreevy's BBB-4 VLF receiver.



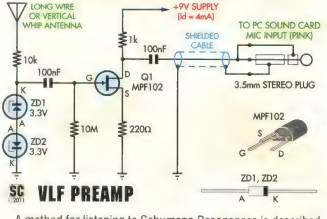


A WR-3 receiver without housing or antenna – a cheaper way to purchase this unit but you will have to provide the housing and antenna yourself.

Note that unlike the WR-3 above, this is a kit and does require assembly. The theory of operation is described at http://theinspire-project.org/downloads/pdf/inspire%20Theory_of_Operations.pdf Assembly instructions are at http://theinspireproject.org/downloads/pdf/VLF_Instructions_Apr2011.pdf It is suggested that you look at those first before deciding if you are comfortable building this kit. A simple telescopic antenna is also needed, or a 2m length of wire.

If you want to try to build your own device to receive broadband VLF signals, SILICON CHIP described a simple VLF preamplifier, designed to plug in to your PC sound card input, in the April 2011 issue. The circuit is shown below (this was part of our feature on detecting earthquakes via VLF radio but is just as valid for listening to VLF from space!).

(See www.siliconchip.com.au/Issue/2011/April/Can+Earthquakes+Be+Predicted+By+VLF+Radio+Signals%3F).



A method for listening to Schumann Resonances is described at www.vlf.it/poggi1/schumann.html Also see www.backyard-astronomy.net/schumann_resonance.html

Spectrum Lab (www.qsl.net/dl4yhf/spectra1.html) is a popular free spectrum analyser software program with which natural sounds from the ionosphere can be analysed (as well as it having many other uses). Using this program along with a PC sound card and an active antenna as a front end is described at www.qsl.net/dl4yhf/speclab/natradio.htm The author of that article also notes that even a long wire can be connected to a sound card as a temporary antenna but surge protection is very important or your computer could be destroyed.

Note that receiving the Earth's natural radio signals requires broadband receivers (as opposed to narrow band receivers that are required for receiving many man-made signals). Such receivers have to be used as far away as possible from power lines and so it is best not to use them in cities as the signal will be dominated by 50Hz or 60Hz hum from power lines (frequency depends on what country you are in). A minimum distance from power lines of 500m is suggested but possibly far more is needed for high voltage lines.

VLF fails within the audio frequencies and the receivers are essentially low noise, high gain amplifiers that have their output fed directly into an audio amplifier. No RF conversion is necessary as in a normal radio receiver. The antenna can be a simple long length of wire or magnetic loop antenna.

Schumann resonance around the earth between the surface and ionosphere (not to scale) showing the fundamental mode (a single standing mode wave around the entire planet) and the second and third order harmonics. Image credit: Neotesla at japansk.

The fundamental resonance corresponds to a wavelength of around 38,300km (using the speed of light in a vacuum) which is approximately the circumference of the Earth, explaining why this cavity resonates at that frequency, with a single standing wave around the entire planet.

The wavelength is a little less than the actual circumference of the Earth (around 40,075km at the equator) due to considerations of spherical geometry and due to other effects such as the slight conductivity of air due to the presence of ions. The frequencies vary a little with the changing state of the ionosphere due to day and night variations and the impact of solar storms on the ionosphere.

When a lightning strike occurs, the discharge acts as a huge transmitting antenna and emits electromagnetic radiation over a range of frequencies. This energy is discharged into the wave-guide where components of that energy are reinforced at the resonant frequencies. There is a constant supply of this energy from lightning as there are, at any given time, 40-50 lightning strikes per second worldwide.

The measurement of Schumann resonances has various applications in lightning detection and analysis, monitoring of the ionosphere and space weather and monitoring of climate via global thunderstorm activity.

(The phenomenon of Schumann resonances has been hijacked by "alternative" medicine practitioners and New Age people who attribute all manner of healing properties to these electromagnetic waves which simply cannot interact with the human body because of their extraordinarily long wavelengths. Unfortunately, a vast majority of on-line material to do with Schumann resonance is of a non-scientific nature).

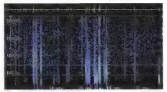
Natural VLF radio signals from lightning and elsewhere

Lightning discharges generate a rich variety of electromagnetic radiation as a broadband pulse, including light, radio waves, X-rays and gamma rays, although much of the energy of the emissions from lightning is in the VLF frequency range (3kHz-30kHz) with some in the ELF range (3Hz-3kHz, the atmospheric science definition of ELF being different to the conventional ITU one).

VLF and ELF waves can propagate over long distances by travelling in the natural ELF and VLF waveguide formed between the Earth and ionosphere. In addition to propagating beneath the ionosphere, some ELF and VLF signals can exit the ionosphere where they will follow the magnetic field lines of the magnetosphere. They can reach 10,000km or more above the Earth before re-entering at a different location.

There are several different types of emissions possible, which are characterised as static, tweeks, whistlers, the chorus and hiss. Note that tweeks, whistlers and the chorus start out as static but by the time they are received they have changed because of the complex path they have taken to the receiver.

Lightning strike "static"

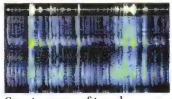


Spectrogram of static signals. Audio of this signal can be heard at www.spaceweather.com/audio/inspire/1lowdenssfer.mp3

Lightning strike static, sometimes incorrectly called sferics (derived from "atmospherics") are the signals from lightning that most people will be familiar with, as they are the same sounds as received on an AM broadcast band radio during an electrical storm. They sound like constant crackling and popping, somewhat like the noises made when someone eats potato chips. The static signals are from lightning strikes within about 1,000km. They are characterised on a spectrogram (frequency on vertical axis, time on horizontal axis) as vertical lines indicating that all frequency components in the signal arrived at the same time.

NOTE: The term sferic should probably apply to all electromagnetic signals that come from lightning, not just the "static" described here; however this static is often incorrectly called a sferic. While that is true, there are other types of sferics as well.

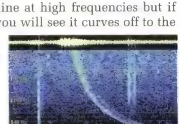
Tweeks



Spectrogram of tweek signals. Audio of this signal can be heard at www.spaceweather.com/audio/inspire/3tweeks.mp3

Tweeks are lightning radio emissions that have travelled from around 2,000km or more distant, within the wave-guide formed between the Earth and the ionosphere. The ionosphere varies in its properties through its thickness so some frequency components will travel faster than others. This is akin to how light travels slower in water or glass than in free space and explains how the colours of a rainbow are generated with a glass prism – some frequencies emerge sooner than others.

Tweeks have a vertical line at high frequencies but if you follow the line down you will see it curves off to the right, indicating that the lower frequencies have been delayed in their arrival compared with higher frequencies. This results in a somewhat musical quality to the signal.



Spectrogram of whistler signals. Audio of this signal can be heard at www.spaceweather.com/audio/inspire/7purewhist.mp3

Whistlers

Like tweeks, whistlers have a musical quality due to the propagation of dif-

ferent frequency components of the signal at different velocities leading to different frequency components of the signal becoming offset in time. It is the interaction of the signal with the plasma environments of the ionosphere and magnetosphere that cause the time delay for the different frequency components. Whistler signals travel along the magnetic field lines of the Earth and can go to the opposite side of Earth and return. Whistlers were discovered in 1886 when a previously unknown noise was heard on phone lines.

Chorus

Two types of "choruses" can be occasionally be listened to on VLF radio, the dawn chorus and the auroral chorus. As the name implies, the dawn chorus is best listened to at dawn and can resemble the dawn chorus of birds, although it has also been described as having a sound like dogs barking or squawks from flocks of birds. It consists of a wide variety of overlapping sounds.

Its presence is dependent upon geomagnetic activity such as the emission of a solar flare from the Sun. The auroral chorus is generated within the aurora and can be heard in areas close to where the aurora occurs and of course is also strongest during geomagnetic activity. A recording of a "VLF auroral chorus" can be heard at https://youtu.be/FQdrcDyYRiQ

Hiss

Hissing sounds are typically emitted via the aurora and are high-pitched when converted to audio. Hiss can also originate in the magnetosphere, including the bow shock region where the incoming solar wind impacts with the magnetosphere.

Above thunderstorm electrical phenomena

There is currently intense interest in the relatively recently-discovered electrical phenomena that occur above thunderstorms, usually at altitudes of 50 to 100km. These electrical discharges are triggered by conventional lightning and have a variety of types that have come to be known as sprites, elves, blue jets, halos, trolls and several other types. Collectively they are known as transient luminous events.

Sprites

An electrical discharge above a thunderstorm was first observed by a US Air Force pilot named Ronald Williams in 1973 over the South China Sea but when he reported it he was not believed as "everyone knew lightning went down not up". Other sightings were later made and reported by other pilots. There is also an anecdotal report from 1730 by Johann Georg Estor of optical activity above a thunderstorm which is interpreted as a sighting of a sprite. It was not until 1989 that Jack Winkler of the University of Minnesota recorded such a discharge by accident when he was looking for something else.

The phenomenon became known as a sprite after the elusive mythical creature with magical powers. Only very powerful lightning causes them and they are much weaker electrically and of shorter duration than conventional lightning.

The first images of sprites from space were taken incidentally as part of thunderstorm videos taken from the Space shuttle during the period 1989-91. Israeli astronaut Ilan Ramon was on the ill-fated Columbia space shuttle crash in 2003 and specifically sought to capture sprite images from space. He managed to transmit several images back to Earth. Remarkably, his camera was found among the crash debris and more images were recovered.

Japanese astronaut Satoshi Furukawa was moved to continue Ramon's legacy and attempted to capture more sprite images from the International Space Station in 2011. He captured images of six sprites and Ramon's work now continues.

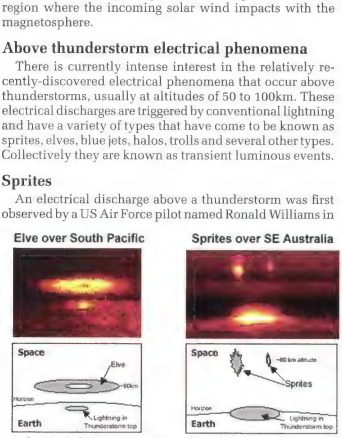
Only one in 10,000 lightning events leads to a sprite. They are believed to be caused when the intense electrical field created by stronger positive lightning bolts causes a sympathetic electrical breakdown of the upper atmosphere. Sprites can reach all the way to the top of the ionosphere but start at around 50km altitude and last around 17 milliseconds. A halo occasionally precedes a sprite (see diagram) and lasts around one millisecond.

Elves

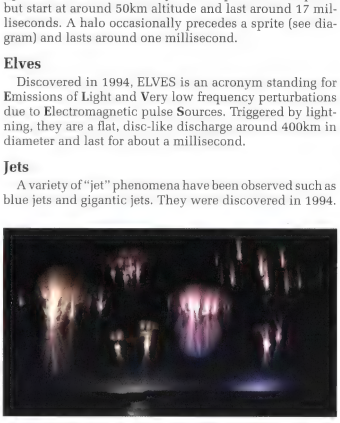
Discovered in 1994, ELVES is an acronym standing for **E**missions of **L**ight and **V**ery low frequency perturbations due to **E**lectromagnetic pulse **S**ources. Triggered by lightning, they are a flat, disc-like discharge around 400km in diameter and last for about a millisecond.

Jets

A variety of "jet" phenomena have been observed such as blue jets and gigantic jets. They were discovered in 1994.



An elve over the South Pacific and two sprites over Australia, captured by astronaut Ramon in 2003 from the Columbia which sadly later crashed killing all seven crew.



A montage of a variety of forms of sprites as seen from jet aircraft on specialised missions to photograph sprites. Image source: NHK.

Lightning detection and tracking

Every time there is a lightning strike, an enormous amount of RF energy is produced. The frequency ranges from the proverbial "DC to Daylight" but the low-frequency energy is attenuated less than high frequencies, therefore is easier to detect.

You'll hear this yourself as crackles and crashes on any AM radio station that's not tuned to a local station – in fact, even a strong, local station can be all but blanked out by a local thunderstorm with lots of lightning. Having said that, the interference from a thunderstorm can be many hundreds of kilometres away if the lightning strikes are big enough!

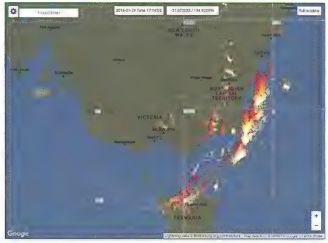
Silicon Chip published a build-it-yourself hand-held lightning detector in the July 2011 issue which relied on detecting this RF energy (siliconchip.com.au/Issue/2011/July/A+Portable+Lightning+Detector). All parts are readily available and the PCB can be obtained from the Silicon Chip on-line shop.

Looking for that burst of "static" is exactly the same process which commercial lightning tracking services use, although they use multiple detectors around the world and measure the exact time the lightning strike is detected. By triangulation, they can pinpoint the spot where the lightning struck to within a few hundred metres.

We published an article in the November 1996 describing the (then) new LPATS lightning detection system, which used this exact approach. We understand that the company behind this system has now been incorporated into the Weatherzone group (www.weatherzone.com.au) but the theory of operation is much the same.

Weatherzone is a commercial operation (although it has a lot of free weather data, including radar and lightning). On the other hand, Blitzortung.org is a community of volunteer lighting detector station operators, software developers and other system support personnel who run a website which plots lightning strikes around the world in real time.

A related site is LightningMaps.org who take the data from Blitzortung.org and visualise it in various ways. Some links for some third party Apps for mobile devices can be seen at www.lightningmaps.org/apps; a real-time map can also be displayed in a browser on a mobile device without any app, www.lightningmaps.org/realtime

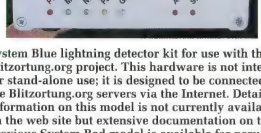


Lightning strikes during a storm in south east Australia on 29 January 2016. The lighter colours are the most recent strikes (less than 20 minutes old) and the darker colours represent strikes that occurred in the past (100 to 120 minutes ago). Map from www.blitzortung.org/en/page_0/index.php You do not need to own the Blitzortung hardware to view a lightning strike map.

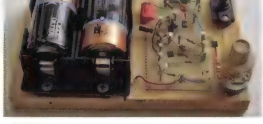
Currently Blitzortung.org has 500 lightning detector stations around the world which are connected via the Internet and there are also numerous servers to process the received data. Each receiver records the arrival of a lightning strike with microsecond precision and the connected VLF receivers locate the position of the strike based on algorithms which use time of arrival and time of group arrival methods.

Anyone can join Blitzortung.org and set up their own lightning detector station which must be made from the kit they supply. The kit of hardware, which must be assembled, can be purchased for under 300 Euros. "System Blue" is the current hardware model of the detector.

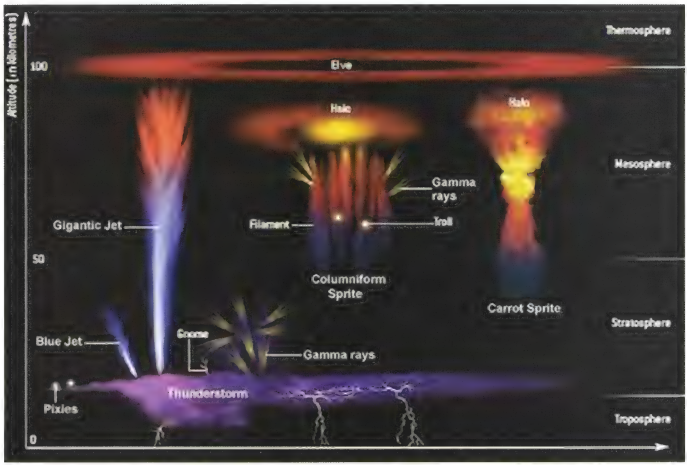
Here are some links to some other DIY lightning detector circuits: www.lissproductions.org/wuhu_manual/2011/11/29/diy-lightning-detectors/ and www.techlib.com/electronics/lightning.html This circuit is said to be very easy to build (see picture): www.techlib.com/electronics/lightningnew.htm



System Blue lightning detector kit for use with the Blitzortung.org project. This hardware is not intended for stand-alone use; it is designed to be connected to the Blitzortung.org servers via the Internet. Detailed information on this model is not currently available on the web site but extensive documentation on the previous System Red model is available for perusal at www.blitzortung.org/Documents/TOA_Blitzortung_RED.pdf



Another DIY lightning detector. See a video of operation at www.techlib.com/files/ld1.avi



Various above-thunderstorm electrical phenomena. As a rough guide of horizontal scale, this diagram could represent around 150km or even more in extent. From http://la.climatologie.free.fr/orage/tle-english.jpg

These start at the cloud tops and rise to about 40 to 50km altitude. Jets seem to be associated with hail activity rather than lightning. You can see one over Darwin, NT in one of the videos referenced below.

Others

Other transient luminous event phenomena include trolls, gnomes and pixies.

Videos of transient luminous events

The video at **http://esamultimedia.esa.int/images/ISS/2005-09-27_Lighting_story/ISS-lyn.avi** is an animation of a variety of transient luminous events.

"*Rare Lightning: Giant Red Sprites, Elves and Sprite Halo's Real Time Video*" **https://youtu.be/D7mqs6fng7o**

"*Extreme Rare Lightning Phenomena - Sprite Documentary - World History*" **https://youtu.be/VzzOQoCkAlU**

"*Lightning Sprites phenomena*" **https://youtu.be/FGMU89tcqeA**

"*Rare Lightning: Giant Red Sprites, Elves and Sprite Halo's Real Time Video*" **https://youtu.be/D7mqs6fng7o**

"*Blue Jet (Transient Luminous Event) - Thunderstorm Darwin 8th Dec 2015*" **https://youtu.be/zLYPKuoxH1c**

"*Upper Atmospheric Lightning: Gigantic Jet*" **https://youtu.be/gk9ju2WUY5Q**

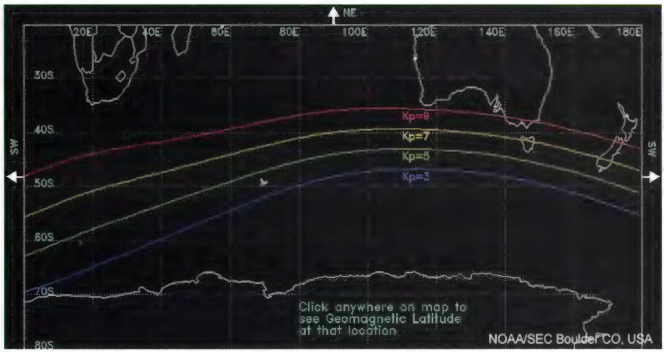
Conclusion

There is a wide variety of interesting electrical phenomena in the Earth's environment and these can be responsible for both spectacular visual displays and can also affect radio listening. Among these are the electric field of the Earth, lightning, the aurora and VLF radio. The amateur can make many interesting observations themselves with simple equipment.

NOTES: Silicon Chip has no commercial association with the manufacturers of any of the devices mentioned in this article. Also, take all appropriate safety precautions when undertaking any possible observations described herein. Circuits referenced that were not designed by us have not been tested by Silicon Chip.

Auroral photography from central Victoria taken at Little Desert National Park by Mark Sansom. It was taken with a Sigma 17-70 lens set to 17mm, f/2.8 and ISO3200 with a 30 second exposure on 13th October 2012.

Viewing the Aurora Australis from southern Australia



Kp lines for a part of the Southern Hemisphere showing the likelihood of visibility of the aurora for a certain Kp index. Note that the Kp is just an indicator, and just because a certain Kp index is achieved it does not mean that the aurora will be visible. Conversely, the aurora may be visible at a Kp of less than what appears on the map for a certain location.

While either of the polar auroras are best viewed close to the poles, it is still possible to view them from southern Australia under certain circumstances with a camera and the Aurora Australis can sometimes even be viewed with the naked eye. The viewing can be surprisingly good, even if not as good as if you were further south (eg, Antartica!).

It is important to choose a night time viewing location which is far from light pollution sources, such as cities and towns and with a clear view of the southern horizon (make sure you really are looking south – check with a compass or smart phone App).

For personal safety it is best to have someone with you and also tell others where you are going and when you are expected back.

The best time for viewing can be determined by a number of smart phone Apps and web resources. There are certain "space weather" numbers to look for that should give the best viewing. Numbers to be considered are as follows:

Bz, the strength of the interplanetary magnetic field in the direction of the rotational axis of the Earth. It is created by waves and other disturbances in the solar wind when it interacts with the Earth's magnetosphere. The more negative the number the better the aurora will be.

Speed and Density of the solar wind. In both cases the higher the number the better, as a greater speed and density of the solar wind will see a stronger interaction with the magnetosphere.

Kp is the planetary index and is represented by a scale from 0 to 9 and is a measure of the level of geomagnetic activity. The higher the Kp index the the further from the poles the aurora should, in principle, be visible however it does not indicate that the aurora will definitely be visible. Rather, Kp indicates that the aurora is likely to be visible in a given region for a certain index based on past experience. Zero represents little or no auroral activity while nine represents a major geomagnetic storm.

Predicted location of auroras updated every 30 minutes at www.swpc.noaa.gov/products/aurora-30-minute-forecast

One website written by a Melbourne-based person to assist mainly Southern Hemisphere auroral viewers is https://auroras.live. It consolidates the main numbers of interest into a user friendly format and the web site is also mobile friendly so can be used on a smart phone in the field.

There are many other websites and Apps covering data related to the aurora and "space weather" in general. One App which you might want to look at is "Aurora Forecast" which is free for iOS and Android but there are many others. Just search the App Store or Google Play with the term "aurora".

Some popular websites for forecasting are www.spaceweather.com/, www.aurora-service.eu/, www.aurora-service.net (Southern Hemisphere) and www.sws.bom.gov.au/ (Australia's Bureau of Meterology). Maps of predicted aurora locations for both hemispheres can be seen at www.swpc.noaa.gov/products/aurora-30-minute-forecast

Some videos of auroras from southern Australia and New Zealand are as follows: "*Aurora Australis (G4) on 17-18 March 2015 at Geelong, VIC*" https://youtu.be/esAUdIIUnFM, "*Aurora Australis (Southern Lights) Point Addis, AUSTRALIA 21 Dec 2015*" https://youtu.be/_4PGJwqC_9Q, "*Aurora Australis : Camera VS Naked Eyes*" https://youtu.be/oq6GO-i7t4Y SC

KCS TraceME

KCS TraceME TM-900 / N1C1

GPS/RF-module / OEM-version

The TM-900 / N1C1 is a budget product line member of KCS' advanced TraceME track and trace modules. The TM-900 is targeted for remotely tracking and tracing a variety of objects, even livestock, and for personal use.

The TM-900 offers excellent long range RF coverage and is equipped with a low-power GPS receiver.

The module is equipped with multiple on-board sensors, low-level I/O-connectivity and a solar (*) rechargeable integrated battery. It offers accurate location based position data to be connected to any existing worldwide server application.

Key Features

- Excellent satellite coverage
  - GPS
  - Glonass/GPS (*)
- Very small, only 49.6 x 15mm
- Lightweight: 3.4 grams for a fully equipped PCB
- Standby battery lifespan of more than 10 years.
- OEM version
- Excellent GPS accuracy, internal antenna.
- Integrated 2.45GHz. radio for special functions and peripherals.
  - Short range, up to 30m (*)
  - Long range, over 1 km range, line of sight
- LoRa™ technology, up to 10km, line of sight
- Excellent indoor and outdoor performance with accuracy up to 1.5m
- 3 LEDs for user interaction.
- 1 switch for user interaction.
- Onboard sensors:
  - Temperature sensor (±0.5°C)
  - 3D accelerometer up to 16g.
  - Humidity sensor (*)
- Wide operating range: -20 °C ... +85°C
- Multiple watchdog levels for maximum stability.
- Solar cell powered (*)
- Versatile interfacing:
  - Digital I/O
  - Serial, 3V
  - iButton™ / 1-Wire™
- Buzzer
- Event based free configurable module to fit any job.
- Remote maintenance. Both firmware and configuration files can be updated over the air.
- Runs local user scripts via .src files.
- Supports integration into third party networks.

Applications

- Object protection, up to 10 years of standby on a single lithium AAA-battery.
- Logistics, M2M
- Animal tracking, asset monitoring
- Security and surveillance
- Remote control and diagnostics
- Anti-theft

(*) Optional, please contact sales for more details.

www.Trace.ME

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KCS TraceME TM-901 / N1C2

GPS/RF-module / OEM-version

The TM-901 / N1C2 is a budget product line member of KCS' advanced TraceME track and trace modules. The TM-901 is targeted for remotely tracking and tracing a variety of objects, even livestock, and for personal use.

The TM-901 offers excellent long range RF coverage and is equipped with a low-power GPS receiver.

The module is equipped with multiple on-board sensors, low-level I/O-connectivity and a solar (*) rechargeable integrated battery. It offers accurate location based position data to be connected to any existing worldwide server application.

Key Features

- Excellent satellite coverage
  - o GPS
  - o Glonass/GPS (*)
- Very small, only 53 x 15mm
- Lightweight: 3 grams for a fully equipped PCB
- Standby battery lifespan of more than 10 years.
- OEM version
- Excellent GPS accuracy, internal antenna.
- Integrated 2.45GHz. radio for special functions and peripherals.
  - o Short range, up to 30m (*)
  - o Long range, over 1 km range, line of sight
- LoRa™ technology
  - o 868MHz. / 915MHz. (*)
  - o Up to 60km line of sight at 25mW and with integrated antenna.
- Excellent indoor and outdoor performance with accuracy up to 1.5m
- Up to 3 LEDs for user interaction.
- 1 switch for user interaction.
- Onboard sensors:
  - o Temperature sensor (±0.5°C)
  - o 3D accelerometer (up to 16g) Optional: (*)
  - o Humidity sensor (±2%RH)
  - o Baro-/Altitude meter (±10cm)
  - o Compass/Magnetometer(1-2°)
- Wide operating range: -25°C … +85°C
- Multiple watchdog levels for maximum stability.
- Solar cell powered (*)
- Versatile interfacing:
  - o Digital I/O
  - o Analog input
  - o Serial, 3V
  - o iButton™ / 1-Wire™
- Buzzer (*)
- Event based free configurable module to fit any job.
- Remote maintenance. Both firmware and configuration files can be updated over the air.
- Supports integration into third party networks.

Applications

- Object protection, up to 10 years of standby on a single lithium AAA-battery.
- Logistics, M2M
- Animal tracking, asset monitoring
- Security and surveillance
- Remote control and diagnostics
- Anti-theft

Ordering information

- TM-901F -
  Full version (Long-range RF, optional Solar-charger)
- TM-901B -
  Basic version (TM-901F without: GPS, Buzzer, Sola-charger, ANT/ANT+)

(*) Optional, please contact sales for more details

Product Summary

Equipped with a state-of-the-art GPS receiver, the KCS TraceME TM-901 / N1C2 module provides reliable and accurate navigational data.

The full version module (TM-901F) is equipped with different technologies for traceability (e.g. GPS/Glonass, LoRa™, Bluetooth LE, ANT/ANT+ and proprietary RF), which can all be combined dependent of the application. The low-budget basic version module (TM-901B) is equipped without GPS while still offering the highly intelligent traceability functionality.

The combined LoRa™ and 2.4GHz. RF technologies offers tracing of the module over a wide area up to 60km. The rough tracing from 60km down to 300 meters is done by LoRa™, while the short-range tracing is done by the proprietary RF-

KCS Trace ME

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technique. This technique offers excellent indoor and outdoor tracing with an accuracy up to 1.5 meters. Traditional national telecom costs are avoided because of the absence of GPRS/SMS.

An intelligent 'Listen before talk' algorithm makes it practically impossible to locate the module which secures the valuable vehicle or asset. It enables stolen object recovery and thereby offers insurance premiums reduction possibilities.

Multiple on-board sensors (temperature, acceleration and optional: humidity, baro-/altimeter and compass/magnetometer) as well as buzzer, LEDs, I/O-functionality and pushbutton enable the integration of TraceME into a variety of custom specific (M2M) applications. With a minimal size of 53 x 15 mm, weight of only 3 grams and a battery lifespan of more than 10 years, the module offers endless OEM integration possibilities.

The functionality of the module can be remotely programmed to fit any job. From basic/general functionality to advanced/low-level application specific detailed functionality.

All of the necessary server-side scripts to process and store data from these units are available for registered distributors and resellers. If you do not want to host data and maps yourself, you can use the hosting services of one of our partner companies.

Specifications KCS TraceME TM-901

Data communication

LoRa™	Semtech SX1272 transceiver
Frequency	868/915 MHz. (*)
Protocol	LoRaWAN 1.0 and custom LoRa™protocol
Transmitting power	up to +20 dBm
Sensitivity	-137 dBm

RF 2.4GHz.	Nordic nRF81422 (BLE only) optional nRF51422 (BLE/ANT)
Frequency	2.45 GHz.
Protocol	BLE 4.0, ANT and custom 2.4 GHz. protocol
Transmitting power	up to +20 dBm (with on-board amplifier)
Sensitivity	-93 dBm (BLE), -90 dBm (ANT)

Navigation (*)

GPS Receiver	Quectel L70 GPS module optional L76 GNSS (Glonass + GPS) module	
Frequency	GPS L1 1575.42 MHz. C/A Code, 48 search channels Glonass L1 1598.0625 ~ 1605.375 C/A Code	
Sensitivity	Acquisition Reacquisition Tracking	-148 dBm (typical) -160 dBm (typical) -165 dBm (typical)
Horizontal Position Accuracy	<2.5 m CEP	

Electrical

Power supply	Internal Lithium AAA primary cell Optional external +5VDC ±10% (micro USB-connector)
Typical power consumption	2mA GPS low power tracking 100mA BLE/LoRa™ transmission 13 uA standby, sensors, timer and I/O active, no transmissions

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External Connections

Power connector

Pin	Description
1	3.4 - 4.5V Battery (+) connection
2	Ground

Power connector (*)

Pin	Description
1	3.4 - 4.5V Battery (+) connection
2	Ground
3	External +4.5 … +5.5VDC, or optional: Solar cell 5V

Micro-USB

Pin	Signal	Type	Description
1	USB VCC	VCC	+4.5 … +5.5 VDC Charge input, max 600mA
2	Serial IN	I	Serial input or digital input (2..31V for active high) ~ 50k pulldown
3	Serial OUT	O	Serial or digital output, open collector (max 31V/10mA/100mW)
4	Analog IN	-	Analog input (0..44V)
5	GND	GND	GND for charge and I/O

About KCS BV

KCS BV, founded in The Netherlands in 1984, develops and manufactures electronics in-house for industrial applications, medical purposes, broad- casting solutions, etc.

Support

Visit our support page at: www.trace.me

Sales

Contact us by email: Trade@trace.me

Final notes & certification

We certify that Kolff Computer Supplies BV, Dordrecht, The Netherlands does not make any hardware or IMEI modifications to the QUECTEL devices as used in the TraceME track & trace device. All software modifications are restricted to official firmware upgrades as provided by Quectel Wireless Solutions Co., Ltd..

Warning

- The device should be turned off in vicinity of petrol pumps, chemical, flammable or hazardous environments where ignition of flammable atmospheres is possible.
- The module and antennas shall be operated at a distance greater than 20 cm from the human body.
- The device is to be operated in accordance with the user instructions or manufactured recommendations.

Disclaimer

KCS BV reserves the right to make changes without further notice to any products herein to improve reliability, function or design. KCS BV does not assume any liability arising out of the application or use of any product or circuit described herein; neither does it convey any license under its patent rights, nor the rights of others.

KCS is ISO 9001:2008 and ISO 14001 certified since 1999.

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How to convert your analog video tapes to digital format

Do you have family videos stored on VHS, Beta or Super 8 video tapes? If so, now is the time to convert them to digital format and save then on DVDs or a computer hard drive, before they become unplayable.

IT'S WELL-KNOWN that analog video tapes degrade with age, eventually becoming unwatchable. This is often due to gradual demagnetisation and/or shedding of the oxide coating, the rate of deterioration generally depending on how the tapes are stored.

To ensure maximum longevity, video tapes should be stored in a cool, dry place. Even so, it's a good idea to convert any precious video material that's stored on tape to digital format as soon as possible.

There are several advantages in doing this: (1) the quality stays the same, (2) you can easily share your home videos on-line, (3) digital media is long lasting and (4) it's easy to make multiple copies.

The digital signal from the converter is fed out to the computer via a Type B USB socket on the rear panel.

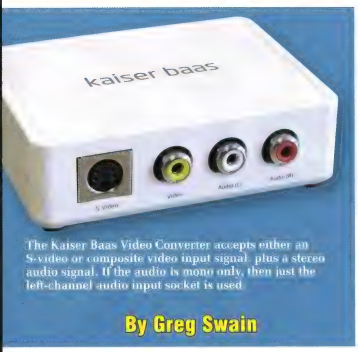
In fact, this article was inspired by a friend who wanted to convert her ageing Video 8 (8mm) tapes to digital format. Her Sony Video 8 camera had long since failed and finding another unit in good working order to play back her tapes proved to be quite a challenge. It took several months to track one down and despite its age, it was almost like new.

Video converter

So just how do you convert analog video tapes to digital format so that they can be saved on a hard drive, flash drive or mobile device, or burnt to a DVD or Blu-ray disc? The answer is that it's easy if you have a DVD recorder with a composite video input – just feed the composite video (and audio) from your VCR or Video 8 camera (or whatever) into the recorder and burn the video straight to DVD. Once that's done, you can burn extra DVDs or copy the files to a PC or laptop.

The problem is not too many people have a DVD recorder with the required composite video input. Or if they do, it's collecting dust sitting on a shelf in the garage because it doesn't work any more.

Once again, there's a simple answer to the problem and that's to use a video converter such as the Kaiser Baas unit featured here. This compact unit can accept either S-video or composite video, as well as stereo analog audio. The A/D circuitry inside the unit converts the incoming analog signals to digital format and spits the resulting digital bits out to your PC or laptop via a USB socket on the back.



The Kaiser Baas Video Converter accepts either an S-video or composite video input signal, plus a stereo audio signal. If the audio is mono only, then just the left-channel audio input socket is used.

By Greg Swain

The supplied software then lets you preview, record, edit and save the video as a computer file.

The Kaiser Baas converter normally sells for around $80 but it's not hard to find it on-line for around $35 (eg, https://www.teds.com.au). Another unit that one of our staff members has found to work well is the Hauppauge USB-Live 2 Analog Video Digitizer. Again, look for it on-line.

There are lots of other units around, some for as low as $10-15. Many of these look just like an oversized USB flash drive and plug directly into your PC. We haven't tested any of these lower-cost units, though.

What's in the box

As well as the video converter itself, the Kaiser Baas unit comes with a software CD, a set of AV cables and a USB cable. Versions of the "Magix Video Easy SE" recording/editing software are included on the CD for both the Windows and Mac operating systems and the CD also includes several PDF instruction files (not that you really need them).

We found that although the software installed OK on a Windows 10 PC, it failed to detect the converter as a USB device. That problem was solved by downloading and installing the latest version from the Kaiser Baas website.

Using it

Using it is straightforward. You simply connect the A/V (audio-video) outputs from the VCR or camera to the converter, connect the converter to a USB port on a PC or laptop and launch the Magix Video Easy software. As shown in Fig.1, the software gives you a choice between creating a new video project or loading an existing project (eg, for further editing). You then choose either a composite or S-video input and then the video source to bring up the window shown in Fig.3 (eg, choose Analog Sources if using a VCR or Video 8 camera).

A video playback preview is then shown as soon as the play button on the VCR or camera is pressed. Similarly, the video will appear if you've loaded an existing project.

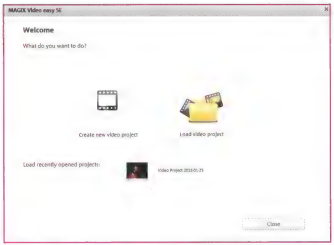


Fig.1: the Magix Video Easy software lets you choose to either create a new video project or edit an existing video project that's already been captured to disc.

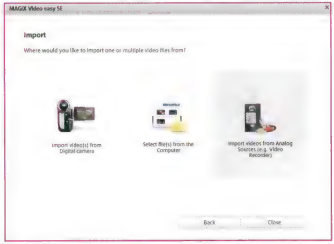


Fig.2: you can choose to import files from a variety of sources. Select the Analog Sources option if importing video from a VCR or Video 8 camera.

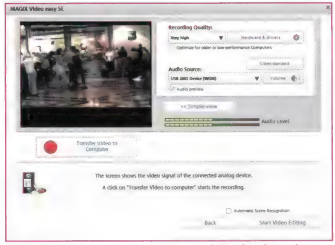


Fig.3: this window lets you preview the video from the connected device. Clicking the button immediately below the preview window then starts the recording process.

This preview lets you adjust the starting point for the recording, before clicking the button to begin copying the recording to the computer. You can also adjust the recording quality, choose the video standard (eg, PAL or NTSC) and adjust the audio level.

The Kaiser Baas Video Converter is supplied with a USB cable, an A/V cable (for composite video and stereo audio) and a CD with the Magix Video Easy software and manuals. It's best to download and install the latest Magix Video Easy software from the Kaiser Baas website, however.

Family movies shot on a Video 8 camera such as this Sony Handycam should be converted to digital format before it's too late to save them.

Fig.4 shows the dialog that appears while the video is being copied. Once copying has been completed (click "End Video Transfer"), you can then edit the file. For example, you can drag the start and finish tabs at either end of the blue bar immediately below the preview window, to set the start and finish of the video (Fig.5). If necessary, you can also adjust the brightness, contrast, colour saturation and hue of the video before saving the file. You can also adjust the speed and even have the video play backwards!

Other editing tabs let you add titles (or text), set font size, alignment and duration, and add audio and special effects. It's then just a matter of clicking the green "Finish movie" button to save the file on the computer, burn it to a video disc, export it to a mobile device or upload it to the internet. The file can be saved in either the WMV or MPEG2 format. SC

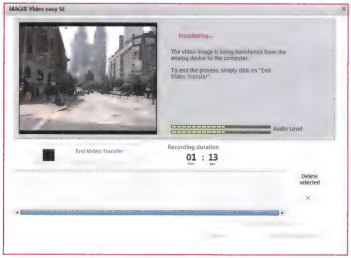


Fig.4: the copying process can be ended at any time by clicking on the "End Video Transfer" button.

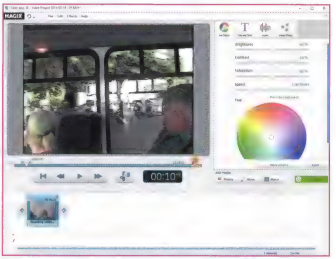


Fig.5: dragging the tabs at either end of the blue bar lets you trim the start and end of the file.

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An alternative Senator Loudspeaker System . . .

. . . for the budget conscious

Did you fantasise about the Senator loudspeakers described in our September 2015 issue? They are certainly impressive, both in appearance and performance. But there is no denying that they are beyond the budget of many readers. Now there is money to be saved, by employing a lower cost woofer and tweeter from Altronics. And you can also save money if you decide to build your own cabinet.

We know that many readers were impressed with the Senators but were dismayed at the cost. The high performance Celestions drivers are quite expensive and then you have the cost of the Bunnings Kaboodle cabinet.

The Kaboodle cabinets certainly have an impressive appearance and professional finish but they bring the all-up cost to around $1700 for a pair.

The performance from the package easily matches that of far more expensive big name loudspeakers with similar characteristics but with prices ranging up to as much as $25,000!

So prompted by appeals from readers, we decided to assess what could be achieved with lower cost, locally available loudspeakers.

It did not take long before a woofer in the Altronics range looked like a reasonable prospect. Sure, it does not have the extreme efficiency and high power handling of the specified 10-inch woofer from Celestion but not everyone wants or needs a loudspeaker capable of a maximum sound pressure level (SPL) of 118dB at one metre – this is extremely loud!

The Altronics woofer in question is their C 3026 which is quoted as having a frequency response from 28Hz to

By Allan Linton-Smith

On the left is the budget version of the Senator with the Altronics 10-inch woofer and 1-inch dome tweeter. They perform well but our preference is for the combination on the right with the Celestion horn tweeter teamed with the Altronics woofer. These cabinets are based on the original Bunnings "Kaboodle" kitchen system – as you can see, these have a highly reflective gloss finish. You can save quite a bit of money by cutting your own panels from MDF and applying your own finish, as detailed in this article.

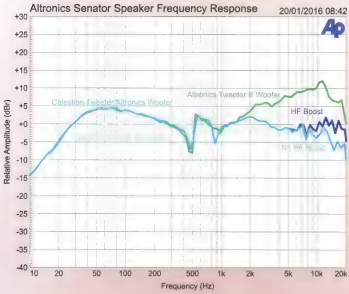

Fig.1 shows the frequency response of the two speaker combinations. The blue curve is the response using the Altronics C 3026 woofer combined with the Celestion CDX1-1730 compression tweeter, mated with the Celestion T1534 horn. The green curve shows the performance with the Altronics 1-inch dome tweeter which gives a rising response to around 11kHz.

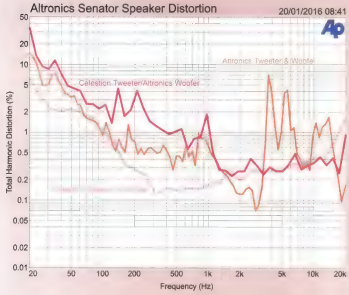

Fig.2 shows the harmonic distortion of the two driver combinations, together with the distortion curve for the original Senator featured in the September 2015 issue (pink trace). The red curve is the combination of the Altronics woofer and Celestion tweeter and it is really quite comparable, especially when the lower cost is considered.

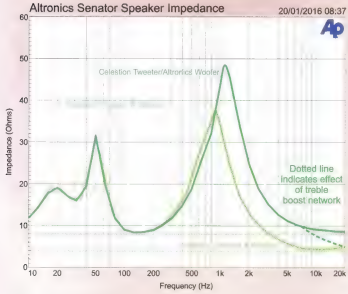

Fig.3 shows the impedance curves of both versions of the budget Senator speakers together with the impedance curve of the original Senator design. None of these will cause any problems for typical hifi amplifiers.

4kHz (with no dB limits), a maximum power handling of 120 watts and an efficiency of 93dB/1W @ 1m. So its power handling is about 4dB down on the Celestion woofer and its efficiency is 3dB less.

That still means that the substitute woofer is capable of very high sound levels in the average lounge room. And the cost for the Altronics woofer? Just $79, including GST.

Now you can still team the Altronics woofer with the Celestion horn tweeter or you can save more money by substituting the Altronics C 3004 1-inch dome tweeter. This has the same efficiency as the suggested Altronics woofer and a rated frequency response from 2kHz to 20kHz (again, with no dB limits). It is much cheaper than the Celestion horn tweeter at $49.50 including GST.

Our preference is for the combination of the Celestion horn tweeter and the Altronics woofer and that is backed up by the measured performance, however the choice is up to you.

Performance

Fig.1 shows the frequency response of the two speaker combinations. As you can see, we achieved a very respectable frequency response using the Altronics C 3026 woofer combined with the Celestion CDX1-1730 compression tweeter, mated with the Celestion T1534 horn.

There are dips around the 500Hz & 1kHz regions but these are simply not noticeable for most types of music. The Celestion tweeter is silky smooth and is really unbeatable on violin strings and cymbals.

The response curve shows the effect of the HF boost facility and this worth doing (if your ears are good enough to perceive the difference!).

We also tested the Altronics woofer combined with the Altronics C 3004 tweeter and as can seen, the tweeter is somewhat on the bright side. Treble boost is certainly not required. Hence our overall preference is for the Celestion horn tweeter.

As already noted, the efficiency of the budget line-up is only a tad less, -3dB, compared to the original Senator but we confirmed it as 93dB/1W @ 1m – and that is still very high compared to the majority of high fidelity loudspeakers which are often rated at as little as only 86dB/1W @ 1m.

That 7dB difference means that

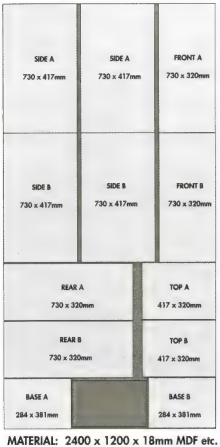

Fig.4: the build-it-yourself version of the Budget Senator can (just!) be cut from a standard sheet of 18mm MDF, with the exception of the reflector board.

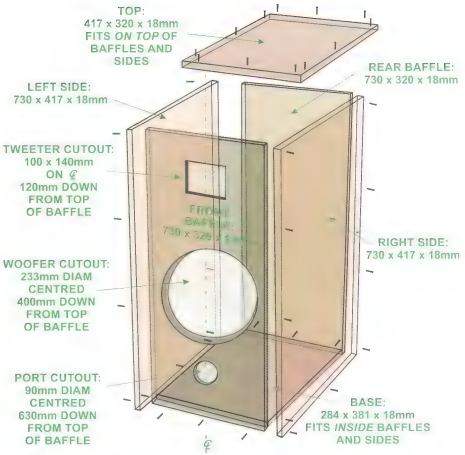

Fig.5: this "exploded" view shows how the panels (which must be very accurately cut) fit together. Not shown here is the 280 x 414mm internal reflector board, which can be virtually any stiff board such as 10mm MDF or even plywood. It is fitted to the rear baffle *before* the top is glued and screwed on.

our budget Senator will potentially be louder with a 50 watt per channel amplifier than a 200W/channel amplifier feeding a typical hifi loudspeaker system.

And remember that many smaller hifi loudspeakers probably couldn't handle anywhere near 200 watts anyway!

The harmonic distortion of our preferred budget Senator loudspeaker system (Altronics woofer + Celestion tweeter) is also very respectable. Fig.2 shows three distortion curves.

The pink trace is the distortion curve for the original Senator featured in the September 2015 issue. The red curve shows the combination of the Altronics woofer and Celestion tweeter and it is really quite comparable, especially when the lower cost is considered.

The orange curve shows the combination of Altronics woofer and tweeter and again, you can see why we prefer the Celestion tweeter.

Finally, Fig.3 shows the impedance curves of both versions of budget Senator together with the impedance curve of the original Senator design and none

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of these will cause any problems for typical hifi amplifiers.

Cabinet construction

Whichever speaker combination you choose, the biggest saving to be made is by building the cabinets from scratch instead of basing them on the Bunnings Kaboodles. If you take the Kaboodle approach, the overall cost will be about $600 for a pair of cabinets, depending on the chosen finish.

For many constructors, the Kaboodle approach will be the easiest and one which assures a very good presentation. Your spouse will love it.

However, if you can make your cabinet, there is quite a lot of money to be saved.

The cabinets can be made of plywood, MDF (medium density fibreboard) or veneered chipboard, with a minimum thickness of 18mm. A single sheet of 2400 x 1200 x 18mm MDF (also known as craftwood) shouldn't cost you much more than $30-$35 – plus any cutting costs, of course.

The biggest hurdle for most people in this process is getting the timber panels precisely cut.

One solution is to go to your local Bunnings Warehouse. They can supply 18mm MDF and a 2400 x 1200mm sheet will suffice for two cabinets – see

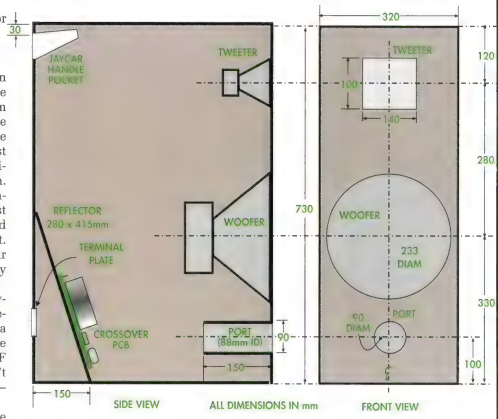


Fig.6: these diagrams are for the D-I-Y version made from MDF or similar and cut to size. The reflector panel needs to be fixed in place (again, with glue and screws) before the top is screwed/glued on. The reflector panel, which is not as wide as the box (ie, there are air gaps between the reflector and the box sides), also makes an ideal place to mount the crossover (which we will look at in detail next month). Wiring goes from the terminal to the crossover PCB thence to the tweeter and woofer.

Budget *Senator* Speaker Specifications

Power Handling:	up to 60W RMS (AES standard, continuous pink noise)
Sensitivity:	93dB / 1 watt @ 1m
Frequency Response:	±6dB 45Hz-20kHz
Distortion:	THD+N ~1% at 1kHz; <2% 250Hz-20kHz; <0.5% 1.2kHz-18kHz <10% 35Hz-20kHz
Impedance:	more than 6Ω from 10Hz-20kHz
Woofer:	Altronics C 3026 10"
Tweeter:	Celestion CDX1-1730 compression driver, mated with a Celestion T1534 horn
Crossover:	2-way first order (6dB/octave slope)

note below. Better still, most Bunnings Warehouse stores can offer a cutting service (for a fee) so you can get all the panels cut precisely.

Fig.4 shows our suggested cutting arrangement for a 2400 x 1200 x 18mm panel. By the way, do not be tempted to use thinner MDF, plywood or even timber.

We are suggesting 18mm as the minimum thickness, to avoid the need for panel bracing to stop resonances. If you want a really rigid cabinet, go for 25mm thick MDF. It will be heavier but the resulting cabinet should be completely non-resonant.

One downside: using 25mm MDF will almost certainly mean that you won't get all the panels from a single 2400 x 1200 sheet, so apart from the higher cost of 25mm MDF, you'll need more of it! The dimensions of the cut panels need to be changed to suit 25mm.

If you do not have a Bunnings Warehouse in your region, we suggest that you get a local kitchen cabinet maker to cut the panels. They have the ability to cut panels with great precision and they can also supply the required MDF, 18mm or 25mm thick.

They can also cut the required holes in the front and rear panels and they may even be able to assemble the cabinets for you but make sure you find out the cost before telling them to proceed.

Once you have the panels cut, the traditional approach is to glue and screw them together with the aid of timber cleats which help with panel alignment. But we have devised an assembly procedure which dispenses with cleats.

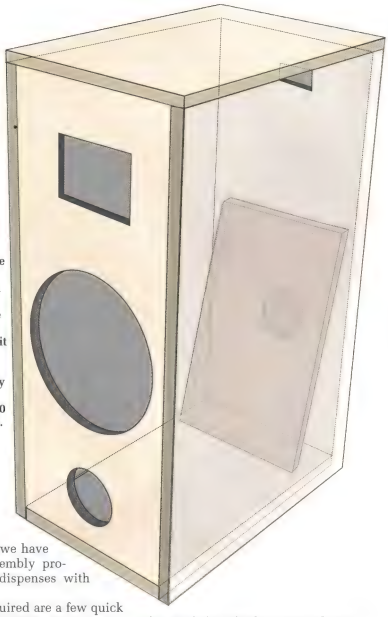


Fig.7: a rendition of a completed enclosure using the lower-cost method of construction, where all 18mm panels are cut from a sheet of 2400 x 1200mm MDF. If you decide to use 25mm-thick panels instead (which will undoubtedly give a better result) you won't get all panels from a single sheet. The reflector board is never seen so it can be cut from just about anything you can lay your hands on between about 10 and 18mm thick.

The tools required are a few quick release clamps sufficiently large to span the width of the cabinet, an electric drill and tube of PVA glue. In fact, if you have a willing assistant, you may be able to dispense with clamps as well.

The exploded cabinet diagram of Fig.5 shows how it all goes together. In essence, you start with the base panel (measuring 284 x 381mm) and proceed to wrap the front baffle, sides and back panel around.

So place the base panel on plastic. Then drill and countersink holes for 32mm chipboard screws in each of the four panels, as shown in Fig.5

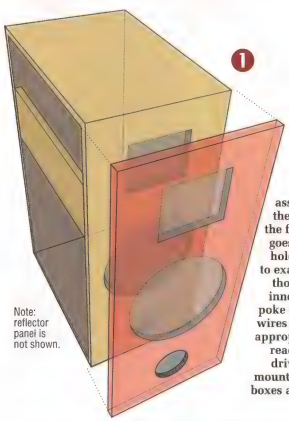
Then run a bead of PVA glue along the mating surface of all four panels. If you have an assistant, he or she can hold each panel vertical and butted up to the base panel while you drive home the screws. (The screws are merely to hold the panels together while the glue sets).

If you don't have an assistant, then you will need to use clamps and in

Just to show the results which *can* be achieved, this photo shows a pair of bookshelf speakers also made from MDF and finished with coats of gloss paint. If you take care and prepare the surfaces properly, you can achieve a very satisfactory result with this approach. We warn you about using a paintbrush, though: you cannot get the brush strokes out! Use a roller – or even better, a spray gun. (See SILICON CHIP, November 2006).

Building the boxes using the Kaboodle approach . . .

For a much more detailed procedure, refer to the original Kaboodle-based Senator Speakers article in the September 2015 issue



After assembling the carcase, the front panel goes on, with holes cut out to exactly match those on the inner panel... poke the speaker wires through the appropriate holes, ready for the drivers to be mounted when the boxes are complete.

Next, the two side panels are glued into place. Make sure you wipe up any excess sealant before it cures. By the way, it's better to leave the protective plastic on the panels until the boxes are finished.

that case, we would suggest glueing all the panels together in one fell swoop. It is easier to do, provided you have sufficient clamps to do the job.

The alternative, gluing panels together in sequence, means that you have to be absolutely sure that each panel is exactly at right angles to its neighbour and that the edges are correctly aligned; otherwise the panels will not fit.

Also make sure that you position the baffle and rear panels correctly, otherwise one or both will end up being upside-down.

The final step is to glue and screw the top panel in place but before you do that, the 280 x 415mm reflector panel must be fitted as shown in Fig.5. You can do this with a combination of chipboard screws and PVA glue as shown in cabinet side elevations diagram – see Fig.6. Before fitting the reflector panel, it's a good idea to mount the completed crossover board on it and attach the wires, including those which run to the rear panel terminals. Or, at the very least, mark and drill the crossover board mounting holes.

Once you have all panels glued and screwed together, wipe off any excess PVA glue while it is still wet. Once dry, it is virtually impossible to remove and you will have to sand any excess flat – which spoils the very smooth finish of the panels.

Leave the cabinet(s) to dry overnight.

Making them look good

OK, while your bare MDF cabinets may be strong, rigid and non-resonant, they will not be objects of beauty. You need to finish them off.

How you do that is up to you but we can describe one method we used to finish similar MDF cabinets in the November 2006 issue.

On that occasion, we used a router bit to machine a 5mm radius on all the corners of the cabinet. This removes the very sharp edges on the panels and the end result looks much better.

Having done that, there are a number of options for finishing your cabinets and this must be done before the drivers and terminals are installed. The approach we used was to paint the cabinets using a high gloss, oil-based enamel.

We started by using an all-purpose acrylic primer, after having thoroughly sanded off all the rough edges.

We also used an acrylic filler to fill the inevitable fine gaps in the joins between the panels and also fill in the countersunk screw holes.

Don't make the same mistake we made when painting the panels. Do not use a brush – you will never get rid of the brush marks.

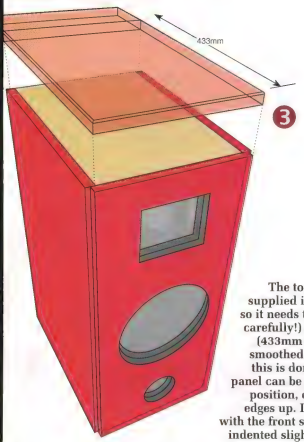
Instead, use a roller intended for applying gloss paint – we learnt by doing! (This assumes you don't have a spray gun, which will give by far the best finish if you know what you're doing!).

After thoroughly sanding it all back, we then used a 50mm foam roller to apply the finish coat. This gives much better results and while you won't get the glass-smooth finish that is attainable with a spray gun, it is much quicker and easier.

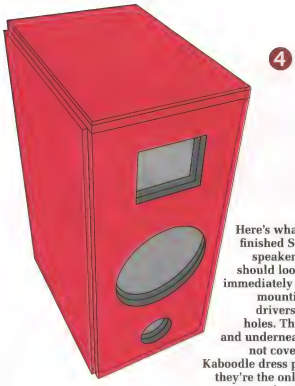
The slightly dimpled finish from the foam roller is also better at hiding any surface blemishes.

Kaboodle cabinets

For many readers, making and finishing their own cabinets will simply



The top panel as supplied is too long, so it needs to be (very carefully!) cut to size (433mm deep) and smoothed off. When this is done, the top panel can be glued into position, chamfered edges up. It sits flush with the front surface but indented slightly (about 8mm) on each side.



Here's what your finished Senator speaker boxes should look like, immediately before mounting the drivers in the holes. The back and underneath are not covered by Kaboodle dress panels; they're the only ones that aren't.

be too hard and not worth the trouble. They will want to take the Kaboodle approach and for those readers we will repeat the main assembly steps, as shown in the illustrations above.

For readers who want more details, you will need to refer to the article in the September 2015 issue.

First step in the Kaboodle process is to assemble the carcase of the 450mm wide cabinet, shown above. This shows the finished carcase which is open on one side, apart from the addition of a 417 x 135 x 15mm MDF brace.

We then cut the holes in what will be the front panel for the tweeter, woofer and bass reflex port. We also cut the holes in what will be the rear panel for the terminal plate and the hand-hold (very handy for lifting the rather heavy finished enclosure).

Budget *Senator* Speaker Parts List

Timber requirements

Cut-your-own-panel version:
1 2400 x 1200mm sheet 18mm MDF
OR (for 25mm MDF) as above plus 1 1200 x 1200mm sheet
1 reflector panel 280 x 415mm x ~10-18mm MDF, ply, etc
Paint etc for desired finish

Kaboodle version:
Kaboodle 450mm wall cabinet (Bunnings Part No W-51623) (16mm HMR panels)
2 end panels (Bunnings: Seduction Red part no D65744)*
1 door (Bunnings Seduction Red part no D65699)*
1 shelf (becomes angled reflector panel) 415 x 280mm
1 side support (113 x 417mm, 16mm MDF or DAR timber)

** Other colours will have different part numbers*
 # Available from Electric Factory (www.elfa.com.au)

Other components required

2 10" woofers (Altronics C 3026)
2 compression drivers (Celestion CDX1-1730#) or tweeters (Altronics C 3004)
2 horns (Celestion T1534# – not required with Altronics tweeters)
2 150mm offcuts of 90mm PVC stormwater pipe
2 terminal plates (Jaycar PT3012)
2 handle pockets (Jaycar HS8012)
8 legs to suit (Bunnings 100mm chrome "Leggz", pack of 4)
4 rolls acrylic fibre (wadding) 700 x 1000mm (Jaycar AX3694)
2 crossover PCB assemblies (see next month)
1 cartridge of neutral-cure silicone sealant/caulking compound
~4m heavy-duty figure-8 polarised speaker wire
~50 40-50mm 10G woodscrews (countersunk head)
16 10g 40mm stainless woodscrews
Miscellaneous screws to suit terminal plates, crossover PCBs and hand-holds

The Speaker Drivers We Used . . .

Apart from the saving in building the speaker boxes from MDF, one of the major cost-saving changes in this version of the Senator speakers is the use of a significantly cheaper woofer – in this case, the Redback (Altronics) C 3026.

While not *quite* as good a performer as the original Celestion woofer (and it must be said, a much lower power handling capability), listening tests at the same relative power levels convinced us that the average person would be hard-pressed to tell the difference between the two woofers.

While there is also a significantly lower-cost tweeter and horn also available in the Redback range, we still prefer the silky-smooth Celestion CDX1-1730 compression tweeter and T1534 horn combination used in the original Senators.

Therefore, we have based this design on the Redback woofer and the Celestion tweeter/horn.

Most people will not require the very high power-handling capability of the original design – the Budget Senator fed by a typical hifi amplifier is more than enough!

As you proceed, there are a few important points to keep in mind:

Leave the protective plastic coating on the Kaboodle gloss dress panels until the enclosures are complete and all the hardware (speakers, crossover PCB etc) are installed. That will minimise scratches and damage from any "oopses". Be especially careful not to drop screwdrivers or other tools onto the dress panels.

All joins must include a bead of silicone sealant to ensure they are airtight. We used bathroom caulking compound which has very good adhesive properties. It is good because it allows you move panels slightly to get the position just right but once it has set, it is extremely strong.

After all, a similar method is used to assemble aquarium tanks. Too much sealant is better than not enough – but be careful to clean up any excess as you go. The longer you leave it, the harder it will be remove.

Openings for the woofers and tweeters need to be cut in the "door" panels.

You will need to cut holes in the cabinet carcase for the loudspeakers etc and you will also need to cut corresponding holes in the front panel for the loudspeakers and the bass reflex port.

These holes are best cut with a jigsaw from the "back" side for best results (so that the gloss exterior finish is not likely to be scratched).

The same comment applies when you need to cut a side panel slightly shorter to act as the top of the cabinet. You will need some 15mm MDF or particle board cut to the dimensions given in the relevant diagram parts list to make up the side support panel.

The four adjustable feet supplied with the Kaboodle kit should be left in their packing until the enclosure is finished and the hardware mounted.

The Kaboodle shelf should not be discarded as it is used to make the angled reflector panel inside the enclosure.

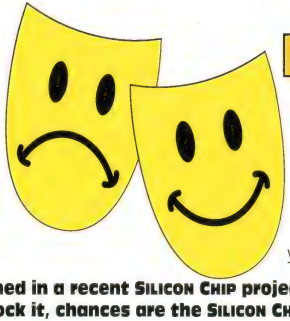
The driver units are mounted using stainless steel screws 10G x 18-25mm, countersunk head. They are the last items to be fitted.

Next month

We'll conclude the assembly of the Budget Senator speakers with details of the crossover, as well as tying up some loose ends (such as wiring, fitting feet, etc). SC

The rear panel of the Kaboodle version showing the input terminal (bottom) and the pocket handle (top). MDF version has these components in the same relative positions.

SAD



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There's a great range of semis, other active and passive components, BIG LEDs, PCBs, SMDs, cases, panels, programmed micros AND MUCH MORE that you may find hard to get elsewhere!

If it's been published in a recent SILICON CHIP project and your normal supplier doesn't stock it, chances are the SILICON CHIP ONLINE SHOP does!

HERE ARE JUST SOME EXAMPLES (oodles more on our website!)

Micromite LCD BackPack kit
Includes PCB, 2.8-inch TFT touchscreen, programmed microcontroller, laser-cut case lid and other onboard parts (Feb 2016) **$65.00**

44-pin Micromite Mk.2 complete kit
Includes PCB, programmed microcontroller, regulator, FT232RL USB interface chip and all other onboard parts (Aug 2014) **$35.00**

MCP1700 3.3V Low-dropout Regulator
3.3V LDO regulator in a convenient TO-92 package, as used in many projects; up to 6V input and 250mA output.....**$1.50**

GPS MODULES
Onboard antenna, 1pps output, cable included VK2828U7G5LF GPS/GLONASS **$25.00**
or VK16E GPS **$20.00**

DS18B20 waterproof digital temperature sensor
Steel-encapsulated digital temperature sensor fitted with 1m lead.....**$5.00**

Micromite Parking Assistant
Ultrasonic distance sensor module and laser-cut UB5 jiffy box lid to suit; interfaces with LCD BackPack kit (March 2016).....**$7.50**

Stereo Valve Preamplifier
Hard-to-get parts: 3 x 39µF 400V capacitors, SMD inductor & shunt resistor **$20.00**
IPA60R520E6 600V logic-level Mosfet **$5.00**

High-Energy Electronic Ignition System / Jacob's Ladder (Nov 2012 / Feb 2013)
ISL9V5036P3 360V, 46A IGBT.....**$10.00**

Low-Cost, Accurate Voltage / Resistance / Current Reference
all SMD Parts (2.5V or 1.8V version), including reference IC **$12.50**

Currawong stereo valve amplifier
Hard-to-get parts including 5 x 39µF 400V capacitors, HV transistor, regulator and blue LEDs **$50.00**

Isolated High-Voltage Probe
Pack of hard-to-get parts including HCNR201-050E linear optocoupler, op amps and HV capacitors & resistors.....**$35.00**

Multi-spark Cap. Discharge Ignition
Pack of hard-to-get parts for the CDI including transformer core, bobbin and clips, SMD ICs, Mosfets & HV capacitor **$50.00**

Mini 12V USB regulator
All SMD parts
With low battery cutout **$15.00**
Without low battery cutout **$10.00**

40V/5A Hybrid Switchmode Supply
All SMD parts including switchmode controller IC, inductor, Mosfets, Schottky diodes plus bobbin inductors.....**$50.00**

SiDRADIO parts
125MHz crystal oscillator, mixer, dual gate Mosfet, 5V relay and more **$20.00**
RF Coil Former pack.....**$5.00**

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Three hard-to-get ICs including CS8416 digital audio receiver, CS4398 DAC and PLL1708 clock generator plus crystal & blue LEDs **$45.00**

Pack of 10 Ultra-bright SMD LEDs
Red/amber/yellow/green/blue; diffused lens
3216/1206 size **75c/10**
2012/0805 size **60c/10**

2.5GHz Frequency Counter
ERA-2SM+ Wideband MMC and ADCH-80A+ Wideband Choke.....**$15.00**
3 blue 4-digit 7-segment displays **$15.00**

Logic-level Mosfets
Pair of IPP230N06L3 N-channel **$5.00**
Or complementary pair of N & P-channel Mosfets (as used in Burp Charger) **$7.50**

PCB mounting RCA sockets
Set of red, white, yellow and black matching, switched RCA sockets. White sockets are hard to find. Suits multiple projects **$5.00**

Bright blue LED with diffused lens
3mm lens, 25mm long leads **25c**
5mm lens, 25mm long leads **25c**
5mm lens, 15mm long leads **20c**

Pair of BSS83 dual-gate Mosfets
Dual-gate SMD Mosfets; discontinued with no direct replacement. Used in the Wideband Active Differential Probe (Sept 2014) **$4.00/pr**

MCP2200-I/SO
USB/Serial interface IC, as used in the Serial Interface project and the Deluxe GPS Timebase (April 2013/April 2014) **$7.50**

TCRT5000
Reflective Optical Sensor, as used in the Automatic Points Controller for model railways (March 2013).....**$2.50**

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USB cameras: use them with your smartphone

This review looks at a variety of USB cameras which are normally intended for use with a laptop PC. But if you are trying to poke a USB pipe inspection camera down a blocked drain you don't want it to be hooked up to a laptop – it is too awkward. The solution: hook it up to your smartphone and use an app like CameraFi.

By Leo Simpson

I have been eyeing off a couple of USB pipe inspection cameras from Jaycar for a while, as they should be very useful in quite a range of situations.

Jaycar have two models: one with a 7-metre long flexible cable and one with a 2.3m flexible cable but in other respects they are identical. The camera itself is only 10mm in diameter and it can be poked into very small openings indeed. And while it is billed as a pipe inspection camera, it has far more uses than that.

Incidentally, they are very often described on the net as borescopes – and even (obviously erroneously) as endoscopes.

Since I was involved in a home renovation, there was quite of lot of wiring and plumbing to be done and I found that the electrician and plumber had not even come across the idea of using a pipe camera for peering into wall and ceiling cavities.

In fact, when running new cables, most sparkies are using the tried and true method of poking a strip of "yellow-tongue" into a cavity and seeing if it can be fed through to the wanted location. Often it can't.

One particularly frustrating job involved installing a lot of LED down-

We've shown this close-up of the 2.3m Jaycar QC3373 for two reasons: you can see the four LEDs alongside the camera lens, with brightness controlled by a knob on the box. Also on the box is a "shutter" button to take a freeze-frame image.

This one is the Jaycar QC3374 which has a the tiny (10mm diameter) camera on the end of a rather stiff 7m cable. In this case the control box is integrated with the USB plug. The mini CD contains Windows software (but not Android).

lights in the this home and trying to run the necessary cables over ceiling joists was time-consuming and labour-intensive. If the electrician had used one of these inspection cameras, some of the frustration could have undoubtedly been avoided.

But there are plenty of other applications where such a camera would be very handy. For example, you could use it check inside the cylinders of many engines (via the spark plug holes).

It could possibly even be used to check for corrosion and blockages inside the water channels of exhaust headers on boats.

Each camera incorporates its own light source in the form of four white LEDs, adjustable in brightness via a tiny knob on the side of a small plastic case in-line with the USB cable.

That same in-line box also has a push-button which can use to take photos or start and stop a video recording.

No batteries are required for the camera since that comes via the USB cable from the PC it is plugged into.

Resolution

The camera has a resolution of 640 x 480 pixels and is quite adequate for the tasks it is likely to be used for. Each camera comes with Windows software on a CD which can be loaded onto a laptop PC (provided it has a CD or DVD-ROM drive) and installation is relatively straightforward.

You can then take the camera and your laptop to the job to be inspected, poke the camera into the job and view the cavity on the PC, take pics or a video.

OK, all good but there are many jobs where you simply don't want to have a camera tethered to a PC.

Can you imagine a plumber trying to inspect a pipe with this camera tethered to his laptop while he stands in a muddy trench in the rain? Neither could I.

But there is an easy solution. Ditch the PC and use your smartphone instead. Virtually every tradesman has a smartphone in his pocket and they are always using their phone to take picture of jobs. The pics can be used for later reference or sent to clients.

And despite all the marketing hype, trying to convince you otherwise, over 70% of smartphones sold in Australia are of the Android variety (although it must be said there are countless camera apps for iPhones as well).

So it is a simple step to hook one of these inspection cameras up to the micro USB socket on your phone. You need an OTG USB female A plug to micro male B plug.

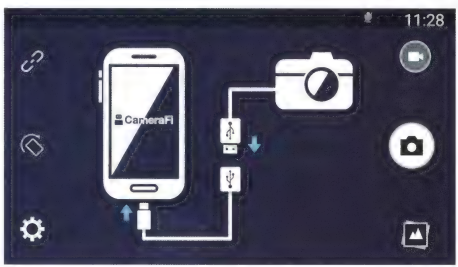
By the way, OTG stands for "on the go" and refers to adaptors while allow USB devices to connect to smartphones etc. Jaycar have a short cable adaptor which will do the job (Cat WC7747).

So that takes care of the physical connection but would the USB inspection camera actually work in this mode?

CameraFi

There are probably more camera apps out there than you've had hot breakfasts but one which we've previously used is CameraFi, a free Android app from www.camerafi.com

So I duly downloaded the Camera-



Here's a screen grab of the CameraFi app from my Samsung smartphone. It not only gives you instructions on connecting your camera (or in this case, the inspection camera) but allows you to set various modes (including movie mode) and a variety of other settings. It's a free download from www.camerafi.com

The proof of the pudding, as they say: this screen shot is taken from the setting on page 46, looking down a large stormwater pipe. You can even see the join in the pipe in this shot – but fortunately, no blockages!

With a focus down to about 50mm (or even less) the camera is more than capable of capturing text, which can then be put through Optical Character Recognition (OCR) software (also available online) and converted to a document file.

Fi app onto my Samsung Galaxy S4, plugged in the inspection camera and it worked first time. It's just so much more straightforward than loading software from a CD into a laptop.

Well, does it work well as a camera in nooks and crannies? Well, yes, sort of...

There are a few wrinkles. First, having the short OTG cable between the camera's USB plug and the phone is a bit awkward, due to the relative stiffness of the camera's cable.

I found it was better to use a compact rigid female USB to micro USB adaptor.

Second, it is quite awkward trying to take a picture using the in-line button on the camera cable. It is more convenient to simply touch the camera logo on the CameraFi screen.

The Samsung phone has a "speech" function to take pics – you just say the word "shoot" and it . . . shoots! But I couldn't get this to work with the app.

Interpreting the image

But the biggest problem tends to be when you are poking the camera down a drain or in a wall cavity and trying to interpret the image.

First of all, Murphy's law ensures that the image you see is not related to the horizontal. It takes some brainpower to work out which way is "up".

And the reason the image tends to be "fuzzy" is that, especially when you're looking in a narrow pipe, say a 90mm storm water drain, the camera will slide along the edge of the pipe. It would be ideal if the camera sat in the centre of the pipe but it usually doesn't. It goes where it wants to go – and in most cases, that's following an edge.

When you do get a clear view, it works very well.

Other USB cameras

What about using CameraFi with other USB cameras, such as a USB microscope camera? I tried it with Jaycar's 5 megapixel USB microscope camera (Cat QC3199) which we featured in the article on magnifiers in the September 2015 issue (www.siliconchip.com.au/Issue/2015/November/Magnifiers%3A+When+You+Want+A+Really+Close-up+View).

Again, it worked really well and it's much more straightforward than using it with a laptop or PC.

Selfie sticks

We cannot finish this article using smartphones without referring to selfie sticks.

Most readers probably regard these devices with disdain and think they are only used by self-indulgent nitwits to post images of themselves and their equally inane transient companions on Facebook or Instagram.

But selfie sticks can be very useful devices when you are trying to look into awkward locations which may well be out of arm's reach.

You only need to use a selfie stick once in this sort of situation and it will have already paid for itself.

By the way, if you do decide to buy a selfie stick, make sure it will "pair" with your phone (it's a Bluetooth connection) before you make the purchase.

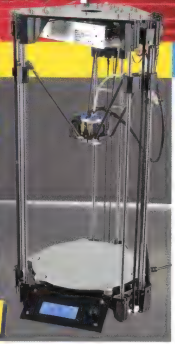
There are quite a few which won't even find another Bluetooth device and even some which won't pair, especially if the smartphone is more modern than the selfie stick **SC**

A typical "selfie stick", fitted here with my Samsung S4 Android smartphone. The stick, which telescopes out from about 90mm to almost one metre, is supposed to "pair" with the phone via Bluetooth to shoot pictures. . . except for one tiny detail – it won't! In my case, I simply take the photo by saying "shoot" to the phone. But if your phone can't do this, make sure you buy a selfie stick that will pair with your smartphone! Inset top left are two types of USB adaptors which are needed to fit an inspection camera to a mobile phone.

GEAR UP FOR WINTER

Give your AV system a tune-up

Jaycar Electronics
Better, More Technical



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Arduino 3D Printer Kit Single Filament

TL-4100 **WAS $729**

This highly capable 3D printer incorporates an elegant open-framed delta design which makes self-assembly straightforward and painless. Use either ABS or PLA filament to make virtually any solid object you wish. The kit includes everything you need to build the printer. The controller also sports an SD card slot, so you can print from the SD card without tying up your computer. The core of the printer is the Arduino MEGA board (included). Kit includes:

- Power Supply
- Motors
- Controller
- Extruder
- Heated Bed
- Maximum Print Size 220mm diameter
- 300(H) x 300(W) x 265(D)mm

$679

SAVE $50

NEW ARRIVALS

NEW

$199

200W 12VDC TO 230VAC Pure Sine Wave Inverter

ELECTRICALLY ISOLATED MI-5726

This 12VDC to 230VAC inverter will allow you to have 230VAC power on the go and includes a 5VDC 2.1A USB power socket to charge your smart devices. Designed to power devices with high initial current demands.

See Website for full details.

ALSO AVAILABLE:
400W MI-5728 **$249**

$14.95

NERD PERKS 2x POINTS

10m Fluoro Green Stylus Gaffer Tape NM-2813

This high quality fluoro green gaffer tape is ideal for highlighting a piece of equipment, avoiding a hazard, etc. 100's of uses.

- Tape sold individually
- 24mm wide x 10m

NEW

ALSO AVAILABLE:
PINK NM-2815

$29.95

NEW

Four Way Stereo Speaker Switch AC-1618

Allows up to four pairs of speakers to be connected to a single entertainment unit or amplifier. 50WRMS power handling.

- 176(L) x 110(W) x 48(H)mm

NEW

$149

Infrared T-Coil Hearing Aid Transmitter & Receiver AA-2099

An ingeniously designed infrared TV Hearing aid system that utilises tele-coil (t-coil) technology for use with most common hearing aids so you can hear the TV program clearly.

ALSO AVAILABLE:
SPARE RECEIVER NECKLOOP AA-2103 **$79.95**

$34.95

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WITH 4 X USB 3.15A OUTPUT PS-4071

This hardwired USB adaptor will fit into a standard GPO wall plate base and give 4 USB power sockets with a total of 3.1 amps.

MORE ARDUINO® ESSENTIALS, MODULES AND SHIELDS ON PAGE 6 AND 7!

$109

Arduino Experimenters Kit

XC-4262

Learn about the exciting world of Arduino® with these easy to build projects. From flashing LED to moving things with a servo. Complete with instructions and a supporting web page and software examples. No soldering required.

$19.95

NERD PERKS 2x POINTS

Solderless Breadboard

WITH JUMPER LEAD KIT AND POWER SUPPLY PB-8819

Ideal for circuit board prototyping and Arduino® projects. The power module can be powered from either a 12V plug pack or from 5V using the micro USB socket with a switchable output between 3V and 5V DC.

- Pack includes Solderless Breadboard with 830 Points, a Power Supply Module, and 64 mixed jumper wires of different lengths and colours.

NEW

$59.95

pcDuino 5MP Camera XC-4364

This 5MP colour camera module connects directly to your pcDuino V3.0, and captures an active array video and images up to 2592 x 1944. Simply connect the included ribbon cable to the CSI (Camera Serial Interface) port on your pcDuino, boot it up, and you are good to go!

- High quality CMOS image sensor (OV5640)
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- 90mm Ribbon

NEW

$9.95

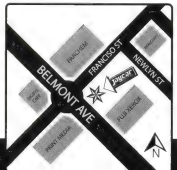
SATA CABLE

FOR PCDUINO XC-4366

Easily connect a SATA hard Drive to your PCDuino using the XC4366 SATA Cable. Designed to draw power for the hard drive from the designated SATA power socket on the PCDuino board. Great for media players or network shares that need more storage.

NEW STORE: BELMONT

53 BELMONT AVE
BELMONT WA 6104 PH: 08 9477 3527



WIRED CONNECTIVITY

Wired Connectivity Up To 30 Metres

TOSLINK FIBRE OPTIC LEADS

1M	WQ-7301	**$15.95**
3M	WQ-7302	**$24.95**
5M	WQ-7303	**$39.95**

FROM $15.95

PREMIUM HDMI 2.0 LEADS

1.5M	WQ-7900	**$29.95**
3M	WQ-7902	**$39.95**
5M	WQ-7904	**$49.95**
10M	WQ-7905	**$99.95**

HIGH QUALITY HDMI LEADS WITH BUILT IN AMPLIFIER

15M	WQ-7432	**$99.95**
20M	WQ-7434	**$129**
30M	WQ-7436	**$149**

WIRED CONNECTIVITY UP TO 100 METRES

HDMI over Cat5e - 100m with IR Repeater AC-1734 — $179

Extend your HDMI signals in the home or office using Cat5e/Cat6 cable. Use your remote control with the in-built IR repeater.

- HDMI 1.3, HDCP 1.1 and DVI 1.1 compliant

ALSO AVAILABLE:

SPARE TCP/IP HDMI RECEIVER AC-1735 **$99.95**

HDMI over Coax - 100m with IR Repeater AC-1740 — $329

Extend your HDMI signal up to 100m using a single coaxial cable. Kit comprises a transmitter, receiver and two power supplies.

- Compliant with HDMI 1.3, HDCP 1.1 standards
- Supports digital video formats in Deep Colour Mode and 48kHz LPCM Digital audio
- Supports resolutions up to 1080p

CAT5E CABLES

Cat5e Blue Patch Leads

FROM $3.25

0.5M	YN-8200	**$3.25**			
1M	YN-8201	**$3.95**			
2M	YN-8202	**$5.25**			
3M	YN-8203	**$6.95**			
5M	YN-8204	**$8.95**			
10M	YN-8205	**$14.95**	**20M**	YN-8207	**$24.95**
15M	YN-8206	**$21.95**	**30M**	YN-8208	**$37.95**

Other colours in various lengths also available. See website for details.

$39.95 PER 30M PACK

Cat5e Solid Core Cable WB-2023

Designed for reliable high-speed network installations . 4 x 24 AWG Solid Core twisted pairs. 30 Metre Pack.

WIRED CONNECTIVITY UP TO 300 METRES

Composite AV over Cat5 - 300m with IR Repeater QC-3681 — $119

Transmit crystal-clear audio and video signals over long distances via economical Cat5e cable. Built-in IR repeater. The signals can be transmitted up to 300 metres on UTP.

- 64(W) x 73(D) x 29(H)mm

SPARE IR RECEIVER AR-1819 **$24.95**

VGA Extender over Cat5 - 300m — $129

AC-1671

Transmits VGA and audio signals across a standard Cat5e cable for distances up to 300 metres. Suitable for VGA cable runs through existing wiring in a wall or ceiling.

- Supports up to 1920x1200 resolution
- Supplied as a sender and receiver pair
- Pluggacks included
- Sender is 100(L) x 65(W) x 26(H)mm
- Receiver is 81(L) x 43(W) x 23(H)mm

MAKE YOUR OWN ETHERNET CABLES

Cat6 Solid Core UTP Cable WB-2030 — $1.75/m

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- 4x24 AWG solid core twisted pairs
- Sold per metre

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VALUED OVER $160

Value-for-money bundle pack to help you customise the Ethernet cable to your preferred length. Cables sold separately.

RJ45 CAT6 CONNECTOR PKT 10	PP-1447	**$13.95**
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6P/8P RATCHET CRIMP TOOL	TH-1935	**$19.95**

2 IN 1 NETWORK CABLE TESTER AND DIGITAL MULTIMETER XC-5078 **$84.95**

CAT5E SOLID CORE CABLE 30M PACK WB-2023 **$39.95**

XC-5078

TH-1935

PP-1447

PM-1441

WB-2023

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SAVE OVER 20%

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$3.95 ea

Quality Gold RCA Plugs

Metal body. Solder type.

RED PP-0230

YELLOW PP-0231

BLACK PP-0232

NERD PERKS 2x POINTS

$3.50/m

Triple Audio / Video Cable

WB-1554

This is a triple cable, 2 for audio and the thicker one for video. It is the same cable that's used in our 3 RCA to 3 RCA pre-made cables. Sold by the metre or by 50m roll for **$130**

NERD PERKS 2x POINTS

$9.95

Waterproof IP67 XLR Line Plug PP-1013

IP67 waterproof plug suitable for harsh environments. Great for use with PA gear and cabling that are used in outdoor conditions

ALSO AVAILABLE SOCKET PS-1017 **$9.95**

NERD PERKS 2x POINTS

$19.95

NERD PERKS 2x POINTS

Cable Tie Box Popular Sizes

400 PIECES HP-1216

This kit consists of: 100 pcs x 200mm, 100 pcs x 150mm, 200 pcs x 100mm.

WIRELESS AND HDMI CONNECTIVITY

Wireless Digital Audio Sender / Receiver AA-2102

NEW

This 2.4GHz digital audio sender uses a 34 channel frequency hopping transmission so you get seamless crystal clear audio.

- Transmission range 30 metres
- Includes two power supplies & audio cables
- Able to be powered by two AA batteries (available separately)
- Stereo

$109

AUDIO / VIDEO CONVERTERS

$64.95

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Compact converter takes a digital optical or coaxial input and converts it to standard analogue left and right stereo audio.

- Bridge legacy sound system with digital sources
- Support up to 24bit / 192KHz via to TOSLINK optical and SPDIF coaxial interface
- 80(W) x 69(D) x 27(H)mm

This DAC accepts 2 channel digital audio only and works with any PCM stream with Dolby Digital or DTS disabled.

HDMI SWITCHERS AND SPLITTERS

AC-1766

FROM $79.95 **4K UHD**

HDMI 2.0 UHD Splitters

Split a single HDMI input to multiple HDMI outputs. Supports all 3D TV formats up to 4K UHD. Supports smart auto switch.

2 OUTPUTS AC-1766 **$79.95**

4 OUTPUTS AC-1768 **$129**

$119 **4K UHD**

4 Input HDMI Switcher WITH AUDIO SPLITTER AC-1707

Supports the latest HD resolutions up to 4K x 2K, 3D video, Dolby TrueHD and more

- Audio formats: Dolby TrueHD, DTS-HD Master Audio 7.1CH
- Inputs: 4 x HDMI
- Video Output: 1 x HDMI
- Audio Output: TOSLINK & 3.5mm Stereo
- 146(L) x 70(W) x 24(H)mm

$129 **4K UHD**

4-to-2 HDMI Switcher WITH UHD 4K SUPPORT AC-1714

4 HDMI inputs and 2 HDMI outputs. Supports resolutions up to UHD 4K x 2K, 3D and EDID.

- DTS Digital, Dolby Digital, DTS-HD and Dolby TRUE HD audio support.
- HDMI 1.4
- IR remote control for switching sources supplied
- 86(W) x 192(D) x 26(H)mm

$109

3G SDI to HDMI Converter AC-1727

These converters allow HDMI equipped TVs and PC monitors to playback uncompressed 2.970Gbps digital footage from cameras supporting this format. Backwards compatible with lower bandwidth SD and HD SDI signals.

- 90(L) x 43(W) x 23(D)mm

ALSO AVAILABLE:

HDMI TO 3G SDI CONVERTER AC-1729 **$109**

IR AND AV EXTENDERS

$14.95

Infrared Panel Mount Receiver AR-1809

Used for creating a clean, flush mounted IR receiver. Simply screw the thread into the wall and connect the 3.5mm plug to your source device.

- 13mm mounting hole
- 28(L) x 17(H)mm

$49.95

Wideband Infrared Extender over HDMI AC-1744

Offers a simple and discrete way to remotely control a cable/satellite receiver, blu-ray player, DVD player, or other home theater source. This HDMI IR Control System is 1080p Full HD 3D Ready and will also work with sources, displays and other electronics connected via high speed HDMI cables. Package includes HDMI Adaptor with IR, IR Transmitter with 1.5m cable, and IR Receiver Pigtail with 1.5m cable

- 20(W) x 15(H)mm

$59.95

4 Way AV Stereo Distribution Amplifier AC-1646

Designed to split a stereo AV signal across 4 channels without loss of image or sound quality. You can wire any room you would like to access audio and video from a central source. Mains plugpack included. Use it to record up to four sources simultaneously.

- 179(W) x 90(H) x 25(D)mm

$149

2 x HDMI to VGA/Component & Analogue/Digital Audio Converter AC-1721

This converter can accept 2 HDMI sources, and has a switch to select which device you want to output. Supports up to 1080p resolution.

- Video Output: YPbPr / VGA
- Audio Output: TOSLINK / 3.5mm Stereo
- 34(H) x 128(W) x 94(D)mm

ADAPTORS, WALLPLATES AND INSERTS

$9.95

Micro HDMI Plug To HDMI Socket Adaptor PA-3649

Connects your Smartphone, camera or other device with micro HDMI socket to any TV with a HDMI connection.

HDMI Wall Plate WITH FLYLEAD PS-0281

Standard Australian/NZ GPO mount with HDMI sockets for AV installations. Comes with a flexible flylead for better inner wall clearance.

$14.95

Keystone Wall Plates

Flush type wall plates to accept our standard keystone 110 jacks. Fits standard Australian electrical switch plate installation hardware and screw centres. Supplied without keystone jacks.

- 70(W) x 114(H) x 6(D)mm

DOUBLE YN-8052 **$2.50**

TRIPLE YN-8054 **$2.75**

QUAD YN-8056 **$2.90**

SIX WAY YN-8058 **$2.90**

NERD PERKS 2x POINTS

FROM $2.50

FROM $2.95 PS-0771

Audio/Video Wallplate Inserts

A range of inserts to cater for computer and Audio video applications. They fit standard 110 keystone wallplates and allow you to configure any way you like.

See in-store for more types

RCA - WHITE PS-0764 **$2.95**

RCA - RED PS-0765 **$2.95**

RCA - YELLOW PS-0767 **$2.95**

HDMI PS-0771 **$9.95**

NERD PERKS 2x POINTS

ANTENNAS AND ACCESSORIES

TV ACCESSORIES

Stereo Audio and Video RF Modulator LM-3880

$49.95

Converts the composite video and stereo audio signal from your DVD player, Pay TV, Camera etc into a standard UHF or VHF TV channel so you can watch the program via the antenna input of the TV.

- Supplied with a 9VDC mains adaptor and 1m Female to Male RF cable.
- 140(L) x 82(W) x 30(H)mm

Digital TV Signal Strength Meter LT-3332

$39.95

Take out the stress from installing your digital TV antenna by using this DVB-T signal strength meter. No more multiple trips up to your roof to get that perfect picture. Connect the pocket sized DVB-T signal strength meter and adjust the angle of your digital TV antenna, the easy to read LED indicator lets you know when you've hit the right spot. Adaptors included. Requires 1 x 9V battery.

- 40-862MHz frequency range
- 50-90dBuV input level

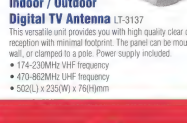
OUTDOOR ANTENNAS AND ACCESSORIES

Outdoor Omni-Directional UHF/VHF Amplified Digital Antenna LT-3141

Inbuilt low noise and high gain booster. Compact and weather resistant. Ideally suited for caravans, boats, and other fixed or mobile applications. Base or mast mounted. Includes mounting bracket. 12V mains power adaptor and 12V in-car charger. 12V mains power adaptor and a 12V in-car charger. Anti-rust and UV protected.

- 350(Dia) x 60(H) receiver dish and 120(Dia) x 70(H) mounting base
- FM 87.5-108MHz
- VHF 174-230MHz
- UHF 470-862MHz

$89.95



Indoor / Outdoor Digital TV Antenna LT-3137

$99.95

This versatile unit provides you with high quality clear digital reception with minimal footprint. The panel can be mounted to the wall, or clamped to a pole. Power supply included.

- 174-230MHz VHF frequency
- 470-862MHz UHF frequency
- 502(L) x 235(W) x 76(H)mm

LT-3181

FROM $44.95

UHF Antennas

TV antennas suitable for medium or deep fringe signal reception areas. Both feature an LTE filter to prevent interference from 4G/LTE mobile networks, which is housed within a waterproof dipole box with F-type connection.

43 ELEMENT LT-3181 **$44.95**

91 ELEMENT LT-3182 **$89.95**

UHF/VHF Digital TV Masthead Amplifier LT-3275

$59.95

Connect a separate UHF & VHF, or a combination UHF/VHF antenna to this amplifier for excellent signal amplification. Suitable for analogue, digital, and HDTV signals.

- Supplied with AC power injector and F-type to PAL adaptors
- UHF 26dB, VHF 18dB input gain
- 125(W) x 102(H) x 45(D)mm

ALSO AVAILABLE:

VHF/UHF MASTHEAD AMP WITH LTE/4G FILTERS LT-3251 **$119**

ANTENNA HARDWARE AND ACCESSORIES

Outdoor Balun LT-3028

$4.95

Mounts on antenna. Converts natural 300 ohm impedance of an antenna to 75 for coax. 'F' type female output. Eliminates saddle clamp termination. Requires F plug.

Adjustable Antenna Mount Bracket LT-3205

$19.95

Ideal for antenna installations with less traditional bargeboards. The base allows for an adjustable angle and contains a mast 1.5mm thick.

- Supplied with mounting hardware.
- 520(L)mm

Antenna Bargeboard Mount LT-3200

$27.95

Simply bolts onto bargeboard (below gutter) or other support. 1800mm long, galvanised steel construction.

- 215mm x 65mm mounting plate

ALSO AVAILABLE:

305MM EVE BRACKET LT-3212 **$24.95**

U-CLAMP/V-BLOCK LT-3235 **$4.50**

Telescopic Antenna Mast LT-3202

With adjustable height and durable aluminium construction, this versatile telescopic antenna mast is suitable for just about any domestic application, marine and mobile use.

- Includes base mount and three guy wires
- Easy installation and height adjustment
- 36mm diameter
- Maximum height 4.5 metres

$64.95

DIY COAXIAL CABLES - ALL THE TOOLS YOU NEED TO MAKE YOUR OWN!

FROM 95¢

NERD PERKS 2x POINTS

F-59 Plugs

PP-0641

F59 connectors suitable for all new TV installations.

F-59 COAX PLUG PP-0641 **$0.95**

F-59 CRIMP PLUG PP-0643 **$1.25**

F-59 SCREW-ON PLUG PP-0638 **$1.45**

F-59 WATERPROOF PLUG FOXTEL APPROVED PP-0708 **$1.95**

F-59 CRIMPLESS PLUG PP-0671 **$2.95**

FROM $1.20/m

NERD PERKS 2x POINTS

RG6 Quad Shield 75 Ohm Coax

High quality 18AWG coaxial cables ideal for RF signalling in satellite dishes, cable bows or TV aerials. Foxtel approved.

QUALITY VALUE-FOR-MONEY WB-2006 **$1.20/M**

PROFESSIONAL BELDEN BRAND WB-2099 **$1.80/M**

$19.95

NERD PERKS 2x POINTS

Rotary Coax Stripper TH-1820

Handy stripper that will strip the outside jacket and inner conductor in one operation. Simply rotate the stripper clockwise around the cable 3 to 6 times. A quality stripper suited to installers.

- Suitable for RG58/59/62/6 and 3C2V 75 ohm cable

$39.95

NERD PERKS 2x POINTS

Ratchet Crimping Tool FOR F-TYPE CONNECTORS TH-1831

A strong, heavy duty tool for crimping F-Type CATV connectors onto RG6 or RG59 coax cable. Ideal for cable TV or RF distributions system installers.

AMPLIFIERS

$189

2 x 50WRMS Compact Stereo PA Amplifier

AA-0488

Uses digital sound processing to deliver the quality of a Class AB amplifier with the efficiency of a Class D. Solid aluminium body, banana socket speaker terminals, stereo RCA audio input, front panel 3.5mm stereo input & 6.5mm headphone socket.

- Includes power supply and audio cables

$219

2 X 75WRMS Compact Stereo Amplifier

AA-0505

This is an unbelievable product.

- A powerful 2 Channel (Stereo) in such a compact size.
- Built-in digital signal processor
- Includes power supply and audio cables.
- 165(L) x 95(L) x 30(H)mm

AA-0477

FROM $269

Dual Channel / Bridged Rack Mount Amplifiers

Very cost-effective solution for a pro audio application. Can be run as dual channel, stereo or bridged. Solid aluminium chassis and front panels.

See website for full specifications.

200WRMS BRIDGED AA-0477 **$269**

400WRMS BRIDGED AA-0479 **$389**

TIME TO UPGRADE YOUR SPEAKER CABLES

WB-1709

FROM $12.95

30 Metre Small Rolls Figure 8 Speaker Cable

LIGHT DUTY 14/0.14MM. GREY WITH BLACK TRACE WB-1703 **$12.95**

HEAVY DUTY 24/.20MM. CLEAR WITH BLACK TRACE WB-1709 **$32.95**

EXTRA HEAVY DUTY 79/0.2MM. CLEAR WITH WHITE TRACE WB-1713 **$74.95**

FROM $1.20/m

Speaker Cables

SOLD BY THE METRE

HEAVY DUTY WB-1706 **$1.20/M**

Suited for speaker systems above 150 watts, 19 x 0.18mm. Black with white trace. Available in 100m roll **$89**

PRO AUDIO WB-1754 **$1.95/M**

Super flexible speaker cable. Separate colour-coded 18AWG red and black conductors in a single outer sheath. Available in 100m roll **$165**

JUMBO WB-1732 **$4.10/M**

For those who want top quality jumbo speaker cable. 259 0.12mm strands in each side. Available in 100m roll **$340**

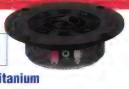
WOOFERS, TWEETERS, AND REPLACEMENT SPEAKERS

$12.95

Piezo Horn Tweeter CT-1930

Does not require a crossover and is perfect for use for general PA applications where long throw is required.

- 100WRMS
- 8 Ohms
- 85(L)x85(H)x70(D)mm



$19.95

25mm Titanium Dome Tweeter CT-2007

This tweeter features a titanium dome with a phase shield which provides a more controlled high frequency roll-off. It produces very crisp and clear high frequencies.

- Power nominal: 50WRMS
- Nominal impedance: 8 ohms
- Sensitivity: 91dB (1W at 1m)

$21.95

70mm Flat Panel "Exciter" Speaker AS-3039

Unlike conventional speakers, this Exciter speaker produces the audio waves by vibrating the flat panel it is fixed to. Designed for where conventional speakers can't normally be used, e.g. ceiling panels, under a table, on a wall partition, behind a fibreglass panel etc. Array them to increase sound level. Sold individually.

- 15WRMS

AS-3007

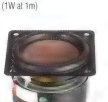
FROM $3.95

All Purpose Replacement Speakers

Suitable for a variety of applications.

See website for full specifications.

57MM 250MW 8 OHM	AS-3000	**$3.95**
76MM 1WRMS 8 OHM	AS-3006	**$4.25**
100MM 2WRMS 4 OHM	AS-3008	**$4.75**
125MM 6WRMS 4 OHM	AS-3007	**$7.95**



FROM $10.95

Full Range Replacement Speakers

Full range speakers suitable for use in home theatre, surround, computer multimedia and portable speakers. Features advanced alloy cone design coated with special damping material.

1" 1WRMS 8 OHM	AS-3030	**$10.95**
2" 10WRMS 8 OHM	AS-3032	**$16.95**
3" 15WRMS 8 OHM	AS-3034	**$19.95**

CW-2198

FROM $39.95

Paper Cone Woofers

These Response woofers are excellent for replacement or new speakers.

8" 90WRMS WOOFER CW-2196	**$39.95**
10" 225WRMS WOOFER CW-2198	**$64.95**
12" 225WRMS WOOFER CW-2199	**$79.95**

NERD PERKS CLUB MEMBERS RECEIVE:

10% OFF SPEAKER CABLES*

**Applies to by the metre cable & pre-cut rolls*

DOUBLE POINTS FOR NERD PERKS CARD HOLDERS ON THESE SPEAKER ACCESSORIES

FROM $2.95

RN-3460

Flyswitches PTC Fuses Speaker Protection

Switches will protect against electrical overload and will protect speakers in most cases. Auto reset.

See website for full range & specifications.

1.5A RN-3460 **$2.95**

5.0A RN-3470 **$4.50**

NERD PERKS 2x POINTS

$4.95

Gold Banana Plugs

Designed for monster type speaker cable.They have a hole entry on the side, with a finger screw down action.- The hole will accept another banana plug or thick cable.

RED PP-0426

BLACK PP-0427

$11.95

2 Way Gold Terminals on a Plate PT-3012

Top quality speaker terminal.

- Plate size 95 x 99mm
- Hole cutout is round - 78mm diameter

NERD PERKS 2x POINTS

NERD PERKS 2x POINTS

$12.50

650gsm Acrylic Speaker Dampening Material AX-3694

Used to line speaker boxes for standing wave/ resonance absorption. Also very effective for making acoustic treatment like bass traps in sound rooms and studios. High density. White in colour.

- 700(W) x 1000(L) mm

See terms & conditions on page 8.

ARDUINO® COMPATIBLE ACCESSORIES

$3.95

Infrared Receiver Module

ARDUINO® COMPATIBLE XC-4427

This module can read the signals sent by most IR remote controls. Pair it with the TX Module (XC-4426) to make a universal remote control.

- 5VDC operating voltage
- 28(L) x 15(W) x 2(H)mm

$4.95

Amplifier Module

ARDUINO® COMPATIBLE XC-4448

This remarkably small module provides a complete 2 x 3W stereo audio amplifier. Ideal for driving small speakers and earphones. Requires no external components.

- 2.5-5.5VDC operating voltage
- 23(W) x 16(D) x 2(H)mm

$5.95

Photosensitive LDR Sensor Module **ARDUINO® COMPATIBLE**

XC-4446

Measure light levels with this sensor module. Connect it straight into your duinotech to build a night/day sensor, a sun tracker or combine it with our laser module XC-4460 to make a laser trip wire.

- 3-5VDC operating voltage
- Includes breakout cable
- 29(W) x 22(D) x 10(H)mm

$7.95

Microphone Sound Sensor Module **ARDUINO® COMPATIBLE**

XC-4438

Great to turn your Arduino® into a voice recorder or vox. Highly sensitive with two outputs - an analogue output for real time microphone voltage signal and a digital output for when the sound intensity reaches its threshold.

- 5VDC operational voltage
- Sensitivity potentiometer adjustment
- 43(L) x 16(W) x 13(H)mm

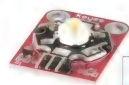
$4.95

RGB LED Module

ARDUINO® COMPATIBLE XC-4428

Using a 5050 RGB LED, by adjusting a PWM signal on the three primary colours the user can gain the full colour spectrum. This tiny module can be interfaced with a variety of microcontrollers.

- 3.3V to 5V operation
- 4 pin header
- Common ground led
- Limiting resistor to prevent burn out
- 25(L) x 15(W) x 2(H)mm



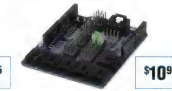
$10.95

3W 200 Lumen LED Module

ARDUINO® COMPATIBLE XC-4468

A high brightness LED in an easy to use modular package. Includes a PWM input for brightness control.

- 5VDC operating voltage
- 6000K colour temperature
- 30(L) x 23(W) x 6(H)mm



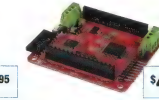
$10.95

Sensor Expansion Shield

ARDUINO® COMPATIBLE XC-4452

Connecting 3-pin analog sensors in a snap. Each of the 6 duinotech analog inputs is broken out to individual 3-pin connectors. There is also a 4-pin communications port that can be set for either UART or I²C. Each of the digital pins is also given a 3-pin vertical header. Plug and Play connection for servos, sensors, switches and more!

- 68(W) x 57(D) x18(H)mm



$44.95

8 x 8 RGB LED Matrix Driver Module **ARDUINO® COMPATIBLE**

XC-4498

Driven by an ATMega328p, this module communicates with your project via I²C. Alternatively, use an ICSP programmer (XC-4237) to flash your own firmware and the device no longer requires an external controller.

- 5VDC operating voltage
- 66(L) x 60(W) x 12(H)mm

$12.95

Motor Servo Controller Module

ARDUINO® COMPATIBLE XC-4472

This versatile board has 2 x 5V servo ports and is capable of driving up to 4 bi-directional DC motors with individual 8-bit speed selection, or up to 2 stepper motors with single/two/interleaved steppings. 5V to 36VDC.

- 4 H-Bridges: per bridges provides 0.6A (1.2A peak current) with thermal protection
- 2 external terminal power interface
- 70(L) x 53(W) x 20(H)mm

$19.95

Data Logging Shield

ARDUINO® COMPATIBLE XC-4536

Store your data to files on any FAT16 or FAT32 formatted SD card, or have it to be read by any plotting, spreadsheet or analysis program.

- 102 solder pads
- Changeable CR1220 battery
- 43(L) x 17(W) x 9(H)mm

$19.95

8 Channel Relay Board

ARDUINO® COMPATIBLE XC-4418

This module provides the easiest way to use your duinotech to switch real world devices. Can switch up to 10A per channel. Includes back-EMF protection and LEDs to easily see the state of the outputs. Includes optical isolation for protection. 12VDC.

- Screw terminals for easy connection to relay contact
- 135(W) x 50(D) x 19(H)mm

$39.95

Ethernet Expansion Module

ARDUINO® COMPATIBLE XC-4412

This network shield will allow you to set up your Arduino® as webserver, control your project over your network or connect to the web.

- 69(L) x 48(W) x 14(H)mm

SAVE 15% OFF THESE ARDUINO MODULES AND SHIELDS

NOW $11.85

SAVE 15%

Sound & Buzzer Module

FOR ARDUINO® XC-4232 **WAS $13.95**

This versatile piezo-element module can be used as a noise-maker for audible feedback of events and as a knock-detector input to sense events and react to them. Includes a built-in 1M resistor to allow the piezo element to detect shocks.

- Frequency response 0-20KHz, peak resonant frequency: 4KHz +/-500Hz
- Sound pressure level at 10cm: 75dB (min)
- 23(W) x 16(H) x 5(D)mm

NOW $21

SAVE OVER 15%

Terminal Shield

FOR ARDUINO® XC-4224 **WAS $24.95**

Breaks out all the Arduino® headers to handy screw terminals, making it easy to connect external wires without using a soldering iron. Ideal for quick experiments or for robust connections!

- Gold-plated surface for easy soldering
- Large prototyping area with through-plated holes
- Clearly marked GND and 5V rails beside prototyping area
- 3 general-purpose surface-mount LEDs (red, green, blue) with current limiting resistors pre-fitted
- Printed PCB overlay on both sides

NOW $33.90

SAVE 15%

H-Bridge Motor Driver Shield

FOR ARDUINO® XC-4264 **WAS $39.95**

Directly drive DC motors using your Arduino® compatible board and this shield, which provides PWM (Pulse-Width Modulation) motor output on 2 H-bridge channels to let your board control the speed, direction and power of two motors independently. Perfect for robotics and motor control projects.

- Drives up to 2A per motor channel
- All outputs are diode and back-EMF protected
- 60(W) x 54(H) x 12(D)mm

NOW $56.95

SAVE 15%

OLED Display Module

FOR ARDUINO® XC-4270 **WAS $**

Light up your display needs with th resolution, full colour OLED displ for graphics, gauges, graphs, e video game or interactive displ

- 16,384 full colour RGB p format
- 44(W) x 35(H) x 5(D)

ARDUINO® PROJECT FOR NERD PERKS CARD HOLDERS

SEE STEP-BY-STEP INSTRUCTIONS ON www.jaycar.com.au/diy-udcr

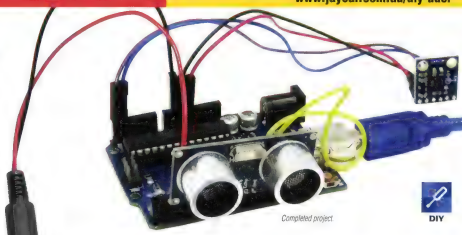
Build Your Own Ultrasonic Distance and Compass Reader

Tim our resident genius (and designer of the Arduino projects we highlight each month) had an altruistic motivation in designing this project. Tim says..."This project measures the distance in front of the sensor, establishes the compass bearing and distance and then reads it out aloud – It's the the sort of thing that could be used to help a visually impaired person navigate".

VALUED OVER $63

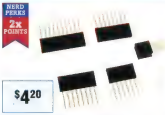
BUNDLE DEAL INCLUDES:

DUINOTECH UNO BOARD XC-4410 **$29.95**
ARDUINO COMPATIBLE ULTRASONIC SENSOR XC-4442 **$7.95**
PLUG TO SOCKET JUMPER LEAD 40 PACK WC-6028 **$5.95**
MAGNETIC COMPASS MODULE XC-4496 **$9.95**
STEREO LINE SOCKET PS-0134 **$1.95**
150R RESISTOR PK.8 RR-0552 **$0.55**
STEREO HEADPHONES AA-2090 **$6.95** *(Not shown)*



NERD PERKS CLUB
BUY ALL FOR $49.95
SAVE OVER 20%

DOUBLE POINTS FOR NERD PERKS CARD HOLDERS ON THESE PRODUCTS



$4.20

Stackable Header Set

HM-3207

It is the perfect accessory for the ProtoShields and vero type boards when connecting to your Arduino® compatible project.

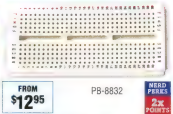
- Includes 1 x 10-pin, 2 x 8-pin, 1 x 6-pin, 1 x 2x3-pin (for ICSP)

$11.50

Polymorph Pellets

NP-4260

It's a commercial grade thermoplastic that softens enough to be formed into any shape at around 62 - 65° C. You simply heat the pellets in hot water or with a hair dryer. It can be drilled, sanded, ground, machined or heated and reformed again and again. Supplied in a 100g bag of 3mm pellets



FROM $12.95 PB-8832

SOLDERLESS BREADBOARDS

Three sizes of breadboards to suit all your project needs.

300 TERMINAL HOLES PB-8832 **$12.95**
630 TERMINAL HOLES PB-8815 **$14.95**
1280 TERMINAL HOLES PB-8816 **$43.95**

$13.50

Breadboard Jumper Kit

PB-8850

This kit consists of 70 pcs of single core sturdy wire which has been stripped on each end and bent at right angles. They are specifically made for breadboards. Supplied in a plastic box for easy storage. There are 5 pieces each of 14 different lengths.

PCDUINO! 100% ARDUINO® COMPATIBLE

PCDUINO + 7" LCD TOUCHSCREEN BUNDLE

VALUED OVER $327

The perfect bundle to create your own in-car or home cinema media player!

BUNDLE DEAL INCLUDES:

PC DUINO V3.0 WITH WI-FI XC-4350 **$149**
7" LCD TOUCH SCREEN MONITOR XC-4356 **$169**
USB A TO USB MICRO-B LEAD 1.8M WC-7724 **$9.95**

BUNDLE DEAL
BUY ALL 3 FOR $299
SAVE OVER $28

EARN A POINT FOR EVERY DOLLAR SPENT AT ANY JAYCAR COMPANY STORE* & BE REWARDED WITH A $25 JAYCOINS GIFT CARD ONCE YOU REACH 500 POINTS!

**Conditions apply. See website for T&Cs*

REGISTER ONLINE TODAY BY VISITING:
www.jaycar.com.au/nerdperks

See terms & conditions on page 8.

CLEARANCE SAVE UP TO 50%

Wall Plate Socket
YN-8059 **WAS $7.95**
VGA Wall Plate Socket with 4 Keystone Inserts.
See in-store or website for a wide range of keystone inserts.

NOW $4.95
SAVE 37%

4 Input HDMI Switcher
WITH MHL INPUT AND PIP FUNCTION
AC-1708 **WAS $99.95**
- Picture In Picture (PIP) Function
- Built-in MHL Converter on Input 1
- Supplied with MHL cable and mains adaptor
- Up to 4K UHD resolution
- 145(L) x 67(W) x 23(H)mm

NOW $87.95
SAVE $12

Keystone Insert
S-Video - Gold
PS-0769 **WAS $3.95**
An inserts to cater for computer and Audio video applications. It fits standard 110 keystone wallplates and allow you to configure your installation any way you like.

NOW $1.95
SAVE OVER 50%

S-Video 4 Pin Mini DIN Plug to Plug - 3m
WQ-7216 **WAS $22.95**
Premium audio/video cable at a bargain basement price. This high performance non-migration interconnection cables utilising 99.96% pure OFC - 24 carat hard gold plated contacts- 100% shielded metal bodied plugs with positive finger grip & moulded cable strain relief. Recommended for digital or analogue signals. Suitable for home theatre, Hi-Fi, video / camcorder / TV / VCR / editing suites, DVD, satellite. Clean and clear image reproduction.

NOW $11.45
SAVE OVER 50%

SCART Plug to RGB
PA-3667 **WAS $4.95**
Scart plug to 3 x RCA RGB Video. Bidirectional.
ALSO AVAILABLE:
21 PIN SCART CONNECTOR PP-0580
WAS $0.95 NOW $0.70 SAVE 26%

NOW $2.45
SAVE OVER 50%

Speaker Comm Box
WITH WATERPROOF MYLAR SPEAKER
AS-3186 **WAS $24.95**
This small but powerful unit delivers clear voice from either VHF, 27MHz or even HF communications receivers. It is very close to waterproof with a Mylar speaker cone,, the gasketed bezel and IP65 cord entry. Don't let the small dimensions fool you - it is a full 4WRMS rated unit.
AS-3187 - ALSO AVAILABLE:
8WRMS WAS $29.95 NOW $23.95 SAVE 20%

NOW $18.45
SAVE $6.50

In-Line HDMI Resolution Upscaler
AC-1750 **WAS $69.95**
Upscale 720p or 1080p video/audio content from a HDMI source to a new 4K TV that lacks a built-in upscaling feature. This device also includes a HDMI micro B female port allowing your laptop or Tablet connection to a 4K screen.

4K UHD

NOW $59.95
SAVE $10

TRADE AND CONDITIONS: REWARDS / HERO PERKS CARD HOLDERS FREE GIFT, % SAVING DEALS, DOUBLE POINTS & MEMBERS OFFERS promotion ACTIVE [illegible] **ON PAGE 2:** [illegible] **ON PAGE 3:** [illegible] **ON PAGE 4:** [illegible] **ON PAGE 5:** [illegible] **ON PAGE 6:** [illegible] **ON PAGE 7:** [illegible] PROMOTION PERIOD will be allocated to the HERO PERKS CARD after the end of the promotion. DOUBLE POINTS accrued during the PROMOTION PERIOD will be allocated to the Hero Perks card after the end of the promotion.

Australian Capital Territory

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SERVICEMAN'S LOG

Re-keyboarding a Yamaha electric piano

Dave Thompson*

Every now and then, I get a piece of gear from the 1980s that's well worth repairing. That was certainly the case with a Yamaha electric piano that came in recently with noisy pots and half its keyboard not working.

Items Covered This Month

- Re-keyboarding a Yamaha electric piano
- Connoisseur BD2/A turntable
- A tale of five oscilloscopes
- Battery-powered golf cart repair

Well, I just had to go and jinx myself. In a recent column, I mentioned that we hadn't had a good shake in Christchurch for over four years but I neglected to touch enough wood because the gods heard me and delivered two very powerful aftershocks. These have now become known as the "Valentine's Day Quakes".

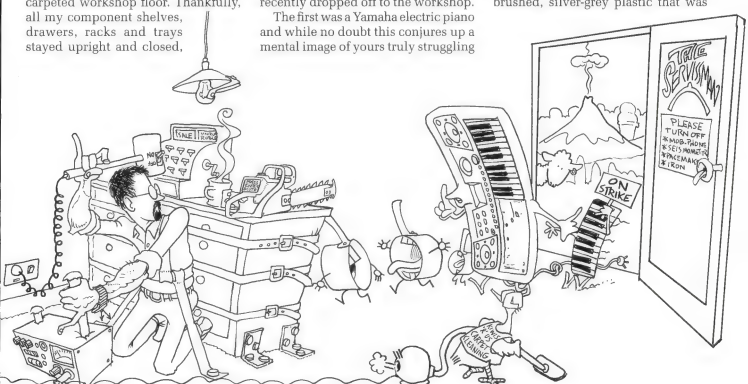
Fortunately, the precautions I had recently taken with my workshop fittings stood up well to the acid test. Even though the quake measured 5.7 (relatively puny to us), the only casualties were a couple of untethered hand tools which fell from my workbench onto the carpeted workshop floor. Thankfully, all my component shelves, drawers, racks and trays stayed upright and closed, withstanding what, to be honest, was a very scary quake.

As a result, I'm satisfied that my workshop is now as quake-proofed as it can be. If anything comes down now, it'll be along with the entire structure and I'll have much bigger things to worry about than a few mixed-up components!

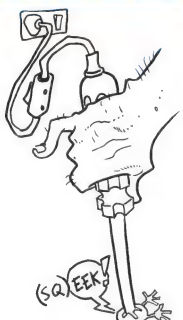
Anyway, as the great philosopher Reginald Perrin once said, "time and motion wait for no man" and so life and service work goes on. After checking that everything was safe and secure, I got down to repairing a couple of musical instruments that customers had recently dropped off to the workshop.

The first was a Yamaha electric piano and while no doubt this conjures up a mental image of yours truly struggling up the driveway with a shiny, black grand piano on his back (a feat I actually witnessed my grandfather doing with our upright piano way back when I was a lad), I have to disappoint you. This Yamaha was a much smaller instrument and while it didn't boast the full 88 keys of a normal-sized piano keyboard, it was none-the-less still a comprehensive machine compared to some.

Built back in the mid-1980s, this keyboard looked like something from "Back To The Future". It used that brushed, silver-grey plastic that was



A YAMAHA ELECTRIC PIANO CAME IN RECENTLY WITH NOISY POTS AND HALF IT'S KEYBOARD NOT WORKING...



~THESE SCREWS GAVE A SATISFYING SQUEAK AS THEY LET GO UNDER THE TORQUE OF MY ELECTRIC SCREWDRIVER...

so popular on commercial electronic equipment of the time and the various stickers/menus and large function buttons boasted all the pinks, pastels and now-faded Day-Glo colours that defined the era. This was the keyboard equivalent of a human wearing a white suit jacket over a T-shirt, baggy linen pants and Italian loafers with no socks!

By now, most of this instrument's contemporaries are padding out landfills all over the globe. However, this one had been well-loved and, outwardly at least, appeared to be in very good nick. Unfortunately, things weren't too good inside the unit because it was no longer working properly.

The owner, a baby-boomer who lives by the same "why chuck it if it can be fixed" ethos that I subscribe to, made the comment that he'd had other keyboards since buying this one brand-spanking new back in the day but not one had the sound and feel that this one possessed. As a result, he wanted it assessed and, if possible, fixed.

The basic problem was that only half of it worked. The in-built rhythm machine and pre-programmed accompaniment sections still sounded spot on (albeit with a typical 1980s' flavour) but many of the 25 black and 40 white keys made no sound at all, apart from the dull, plastic-mechanical thud you get with most electric piano keyboards. Not only that but many of the numerous linear/sliding sound modification and volume control pots that were popular on electronic devices at that time were now distinctly electrically noisy in their operation.

No problem, I thought; these were all age-related issues and most, if not all, such keyboard instruments would likely suffer similar maladies over time. Given that this one was now around 30 years old, it wasn't surprising that it was no longer working properly!

Stripping it down

Disassembling it was relatively straightforward. Once I'd placed a large piece of foam-rubber on the workbench (that I specifically keep for such jobs) and flipped the keyboard over, I could see that the top and bottom "halves" were held together with several large machine screws. Most of these screws gave out a satisfying "squeak" as they let go under the torque of my electric screwdriver, indicating that this was probably the first time that they had been removed. What's more, none were those annoying "security" screws that modern manufacturers seem to be in love with, making it a breeze to work on.

Once the case had been cracked, I then had to disconnect several flying leads which ran from various terminals on the circuit boards in the top section to other connectors built into the bottom half of the case and to the battery holder. Only then could the two halves be separated, so that was a potential trap for young players too eager to gain access.

Once the insides had been exposed, the reason for the keyboard's intermittent operation was immediately obvious; dust-bunnies, hair-balls and cobwebs choked every possible nook and cranny of the interior of the case.

Basically, over the last 30 years, a collection of pet hair, dust, dirt, sweat, cigarette ash, tobacco, insects, beer and other debris had fallen through the gaps between the keys and into the various open compartments beneath. This had simply built up until it started interfering with the electrical operation of the keys.

It was also apparent that much the same fate had befallen the pots. Where once a thin, split-felt dust-cover protected the inner workings of the pots, this had now all but gone after years of wear and tear. Anything with gravity on its side now had free entry into the insides of the pots, so it was no wonder they sounded like fingernails being dragged down a blackboard whenever they were operated!

The keys were made from injection-moulded plastic, formed into the shape and colour of traditional ebony and ivory piano keys. The quality of the mouldings and the whole keyboard assembly was very good and while the main part of each key underneath the keyboard "floated" in free air, the upper portion of each key disappeared between a felt-edged plastic moulding and a PCB that ran the length of the keyboard. Obviously, this was where all the action took place and I'd need to get in there in order to get a good look at the springs, contacts and other parts that made up the keyboard.

The keys on this type of instrument are essentially just a line of push-to-make, release-to-break switches, with each switch controlling an oscillator that's modified with various filters to emulate the sound of a piano note (or in some cases, used to trigger an actual sampled piano note sound). Cheaper keyboards typically have limited feel and action and no matter how hard you hit the keys, the output level remains exactly the same.

On the other hand, the better (and usually more expensive) keyboards are dynamic, which means that just like on a real piano, if you just touch the key, you'll get a very quiet note and if you press the keys harder you'll get a proportionally louder sound. Good keyboards are thus designed to mimic the feel and action of a real piano, making the playing (and listening) experience far more satisfying.

This Yamaha model boasted a dynamic keyboard, so I was expecting some complicated mechanics under that long PCB. This PCB is about 80mm wide and spanned the entire length of the instrument, making it about 750mm long. It was held down by 24 equally-spaced flat-head screws and a similar number of plastic clips, which made me glad I had an electric screwdriver on-hand.

As an aside, while old-timers tend to frown on mechanised screwdrivers

(and to a point, I agree with them), the electric screwdrivers made today are not the clumsy devices of yesteryear that stripped threads. Instead, they are now smaller, easy-to-use tools that, provided they are set properly, will not damage anything and which make repetitive jobs far easier.

If you have all day to spend undoing multiple screws by hand, then go for it. However, those of us who are time-poor or on the customer's dollar can use all the help we can get.

Once all the screws had been removed, I carefully lifted the board away from its locating posts and clips and watched carefully for any springs, magnets or ball-bearings that might fly out and hide in the carpet. However, all I could see falling out as I lifted it away were bits of fluff and dust, with most of it dropping onto the rubber mat underneath the keyboard.

After vacuuming up all the visible dust and dirt, I had a much clearer view of what was going on. In fact, anyone who has ever pulled a numeric keypad apart would recognise the technology used in this keyboard. Each key has a corresponding collapsible rubber button contact shaped like a small thimble beneath it and this, when pressed, makes contact with printed graphite or carbon contacts etched into the PCB beneath it.

In this case, the rubber buttons were all part of a 750mm-long contact pad which simply lifted out. When laid out on the bench, it looked like a long, narrow rubber strip mat with small, stepped thimbles aligned along its length, with each thimble corresponding to a key position.

When I turned this flexible mat over, I could see a carbon contact inside each of these rubber thimbles. In fact, each contact was composed of three sections. First, there was a small, round carbonised pip in the inside centre of each thimble and when this was pressed, it sat directly down onto the centre of its corresponding PCB contact.

Next, on the outer-bottom edge of each thimble, were two more carbonised pad contacts, one on each side of the thimble but set slightly higher. These made contact at a different spots on the board contacts when the keys were pressed downwards and my guess is that these contributed to the dynamic "feel" of the keyboard.

Obviously, the contacts on the rubber thimbles have to be clean in order to make proper contact with the PCB. And of course, the PCB contacts themselves must also be clean and clear of any debris.

Years of dust & dirt

As it stood, years of accumulated dust and dirt had coated the various contacts and as each key was pressed, some of this rubbish had transferred onto the rubber pads. This very effectively prevented any connection at all being made at those points, which was why half the keys didn't work.

I began by vacuuming up as much of the mess as possible but I was already thinking that I'd have to go a few steps further to really make sure the keyboard was as good as new. My next step then was to flip the rubber contact pad over so that all contacts faced upwards. I then went down the line with a can of contact cleaner and gave the first half dozen or so a good blast. This was a little messy but it was necessary to blow off any rubbish.

I then quickly followed that up by pressing each thimble from the back, thus exposing all the contacts, and going over it with a home-made contact-cleaning wipe. This effectively gave the inside bottom of each thimble a thorough clean, after which I repeated the process for the next six keys.

This step-by-step process was necessary because contact cleaner evaporates pretty rapidly and I wanted to get the wiping done while there was still a small pool of cleaner left inside each thimble.

Once I'd processed and cleaned all the rubber contacts, I set the now sparkling clean mat aside and concentrated on the other half of the equation – the circuit-board contacts. A potential problem here is that if a keyboard has seen a lot of use (eg, a home telephone keypad or a TV remote control), there's a chance that its etched contacts have worn away for the most-used keys. And if that happens, no amount of cleaning is going to replenish those contacts and the only way out is to replace the board itself.

Replacing the PCB obviously wasn't going to be an option here so all I could hope for was that this keyboard hadn't been used enough to wear out its PCB contacts. Fortunately, when I inspected the board with my much-used USB microscope, I could see that all the contacts appeared to be in good condition underneath, although they were covered in a thin layer of greasy dust and dirt. Once more, my trusty can of contact cleaner and wipes made short work of cleaning the contacts and this revealed they really were in excellent condition.

In the past I've had good luck with keypads by cleaning them exactly as described above, then giving them a very light rub over with some Scotch-brite or similar plastic scouring pad. However, note that getting stuck into the contacts willy-nilly with scouring pads is never a great idea. Instead, a

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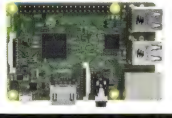

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Connoisseur BD2/A turntable

G. K. of Morningside, Qld recently resurrected an old Connoisseur BD2/A turntable, so that he could listen to LPs once more. Along the way, he discovered why he could never get it working properly when it was new . . .

This story was prompted by the SILICON CHIP turntable strobe project in the December 2015 issue. It immediately reminded me of the work I recently did restoring my Connoisseur BD2/A turntable. Yes, the Connoisseurs used a synchronous motor but I have repaired an old Thorens and an old direct-drive CDC turntable too, so the strobe project is handy.

When I first got my BD2/A home, I was not happy with the its sensitivity to vibration and so I bought and built a variety of damping feet for the chassis. The was only moderately successful because it still wasn't good and I could never set the anti-skating bias properly.

When I started the restoration, I decided to see if there was anything on the internet for such an old turntable. This was a revelation; I easily found all the manuals and I discovered that the original supplier had assembled the chassis incorrectly from the outset. As a result, I re-assembled it correctly and, after fitting some new DIY damping feet, it's now fine.

The manuals I downloaded also referenced two bias weights for the pick-up arm: a large one for heavy cartridge tracking weights and a small one for lighter tracking weights. On my unit, the large (2.5g) bias weight had been fitted to the pick-up arm so it was no wonder I could never get the bias right!

As well as this, the small weight necessary for low tracking-weight cartridges, such as the Stanton 680EEE, was missing. In fact, it was never supplied and nor was the additional pick-up arm counter-weight described in the manual (although it hasn't been missed).

I guesstimated that a 1.25g bias weight might work for low tracking weight cartridges, so I filled the hole of a steel M3 nut with solder, thinking this wouldn't look too out of place with the rest of the chrome on the pick-up arm. I then drilled through the solder and lined it with liquid insulation "tape" so that it would be a soft push fit over the bias weight shaft. It turned out to be pretty close to 1.25g and I can now (finally) adjust the bias to match the cartridge tracking weight.

The rubber motor suspension had perished and sagged due to Queensland's heat and humidity, so I made up a replacement from a motor-cycle inner tube. This also worked well and a search on the internet revealed that several other owners had also resorted to a DIY solution for the motor suspension. Genuine kits are still available as well.

At that stage, I took a look at replacing the cartridge. When CDs originally began to supersede LPs, there were some cartridge and stylus bargains to be had as retailers disposed of their older technology. Fortunately, I acquired a couple of spares for very good prices at the time and had put away them in drawer. They turned out to be a good investment.

In 2001, I went away for a holiday with my wife and when we returned, I found that one channel of our stereo system was out when listening to LPs. It was only missing when listing to LPs, so that immediately narrowed the fault down to the turntable and its connecting leads.

I went through the signal path checking for continuity and ended up back at my 680EEE cartridge. One channel was open circuit and I initially thought that this was probably due to misuse by our adult children while we were away.

Anyhow, with nothing to lose, I tried a "blacksmith trick" and heated the pins on the offending channel on the cartridge. This very light rub with a (preferably used) section of a pad can clean the contacts and provide the rough surface area they require for a good electrical contact.

Having given them the Scotchbrite treatment, a final wipe down to remove any lingering debris was all that was needed to restore the PCB contacts to as-new condition.

The reassembly procedure was simply the reverse the disassembly process and after laying down the rubber mat, lining up the circuit board and "torqueing" the screws down, I was ready to test it out. Annoyingly, while most of the previously non-working keys now worked, several still didn't, which put a real dent in my confidence. I was sure I'd cleaned all those contacts properly, so there was nothing else for it but to take it apart again and try to figure out where I'd gone wrong.

This time, as I removed the circuit board, I noticed that the rubber mat was ever-so-slightly out of alignment in some areas. This meant that the rubber thimbles in those area did not get compressed directly onto the PCB contacts under key pressure.

I relaid the mat, this time making sure that every thimble lined up perfectly with its corresponding key. I also made absolutely sure that it was dead flat before I screwed the PCB down.

As a precaution, I put in just the barest minimum number of screws necessary to keep it together, in case it had to come apart again. Then, keeping in mind that if I did a Jerry-Lee Lewis on it I'd likely blow the board right out from under the keys, I gently tried each key in turn and they now all worked correctly. I then added the remaining screws and gave it a final workout by playing Rachmaninoff's Prelude in C-Sharp Minor (otherwise known to me as "Chopsticks").

Noisy pots

That left the noisy slider pots. I began by removing these one by one, then disassembled them by carefully bending back the folded metal clips that held the bottom section to the main body of each pot. After removing the knobs, the sliding assembly could then be removed, exposing the tracks and the sliding contacts.

Each pot was then cleaned in turn using contact cleaner and wipes and given a gentle rub with Scotchbrite. They were then reassembled and that fixed their noisy operation.

Sliding pots are becoming hard to get these days, so being able to clean and restore them was a lucky break. However, they'll almost certainly need replacing when the keyboard comes back in for another service in 30 years time!

A tale of five oscilloscopes

Despite having a good working scope, R. B. of Denistone, NSW decided to tackle four faulty units that were sitting unloved in his workshop. He managed to get three of them going again but the fourth had to be binned. Here's what happened . . .

made no difference so replacing it with one of the spares I'd invested in was the obvious solution. I subsequently fitted the new unit in place and then went through all the measurements and adjustments to get the correct horizontal and vertical tracking angles and the correct tracking weight, etc.

Unfortunately, when I attempted to play some music, I now got intermittent dropouts and crackles! This led me to wonder what I could possibly have damaged, since during the initial diagnosis I'd had the turntable apart to check the pick-up arm connection (and there are very delicate wires in there).

I went back through the signal path again and that led me straight back to the cartridge. Fortunately, the source of the drop-outs turned out to be nothing more than a coating of "gum" that had built up on the pins of the cartridge while it had been stored in a drawer in the sub-tropics for many years.

So here's a tip for analog music listeners: always clean replacement cartridge pins before plugging them in!

This experience also convinced me that it was old age that caused the Stanton 680EEE cartridge to fail, rather than abuse.

Finally, I wonder what my turntable's early history may have been like if the internet had been available back then and I had been able to diagnose and fix some of its problems sooner.

Over the last few years, I have acquired no less than five oscilloscopes. Of these, three subsequently developed faults, while the fourth, purchased secondhand, was faulty to begin with. They'd been sitting around for some time, so I recently decided to tackle them to see if they could be repaired.

I acquired two of these scopes from a well-known local electronics chain and another two via eBay. The fifth (working) unit was purchased online brand new; it was a popular Chinese-made digital scope and it proved to be a great purchase (one that I should have made years earlier).

Scope repair 1

The first faulty scope that I tackled was a BWD 802. This is a 25MHz, 2-channel scope and it worked when first purchased via eBay several years ago. However, it subsequently stopped working a year or two later.

I put it on the workbench and applied power. The "power on" light failed to illuminate and after a minute or two I could smell something burning, so I removed the covers to see if I could spot the offending component.

To say that the blue smoke had been let out was an understatement! The covers of this scope enclosed the chassis very tightly and as I peeled the covers off, a large plume of acrid blue smoke wafted into the workshop. That meant that it shouldn't be too hard to spot the cause of the problem, or so I hoped.

I put the now naked scope on the bench, turned off the power switch on the front panel and connected the mains power. Within a minute, a tantalum capacitor began to expel all its remaining smoke! This in turn raised an important question: apart from the obviously faulty capacitor, why was power being applied to the circuit when the front-panel power switch was off?

I removed the power cord from the wall socket but rather than tackle the switch, I decided to sort out the tantalum capacitor problem first. This device was a smoothing and stabilisation capacitor for an LM7915 regulator and a quick check with a multimeter indicated that it was the only one in the vicinity of the regulator that was faulty. I didn't have any tantalum capacitors on hand but a quick check of the LM7915 data-sheet indicated that a 25µF electrolytic capacitor would do the job. Fortunately, I did have one of these on hand and so this was substituted for the faulty tantalum.

I then plugged the unit into the mains again and this time the power indicator light came on, even though the front-panel power switch was still off. What's more, the scope still wasn't working. I checked the rail voltages and found that I had a -15V rail but the +15V rail was missing in action.

As it turned out, the tantalum capacitor on the +15V rail supply had also failed. This was replaced with another 25µF electrolytic capacitor and the scope then began operating.

So why had these two capacitors failed? Apparently, tantalum capacitors can fail in a catastrophic way. And when they short out, they can draw lots of current and burn circuit boards or even cause a fire. However, the tantalum capacitors in the BWD802 were installed after the voltage regulators, which by design limit the current to just a few amps. That's enough to let the smoke out but low enough to prevent a fire or damage to the PCB.

Now that I had this scope functioning, I turned my attention to the front-panel power switch. This switch is integrated with the intensity control (a potentiometer) and the power is normally switched on by turning the knob off zero. This was a common arrangement up to about the 1980s and basically consisted of a switch mounted on the back of a potentiometer.

A quick check with the multimeter showed that the switch section, which switches both Active and Neutral, was stuck in the "on" position. A quick search on the internet failed to turn up a source for this part and it appears that they are no longer available.

The switch section was held on by two small metal tabs. Once these had been released, I could see the mechanism inside and this revealed that one tiny Nylon part had broken. In the end, rather than try to fix the switch, I decided to discard it and keep the potentiometer section.

After some thought, I decided to make a cut-out in the rear panel and install a combined IEC male socket, fuse and switch. This was wired directly to the mains transformer and the unit is now fully working.

Basically, it pays to have an open mind when repairing old equipment, as it's not always possible to obtain the parts required.

Scope repair 2

The second scope that I repaired was a Protek 6502a, a 2-channel 20MHz scope that I bought from a local electronics chain. It lasted perhaps 15 months before it failed, so it was outside its warranty period.

This scope came with a full set of schematics, so that at least gave me a good chance to repair it. The failure was somewhat curious: the trace was visible on the screen but could not be brought into focus. In addition, it was making a buzzing sound. Changing the focus and intensity controls altered the sound and pitch of the buzz.

This indicated a problem with the circuitry that generates the high tube voltages. I managed to obtain a new EHT transformer from the place where I purchased the scope but changing this had no effect.

I was sure that the buzz was some clue to the problem and that it could possibly be due to high-voltage tracking or arcing. So I carefully checked

the PCB and all components for any evidence of tracking or sparking but drew a blank.

And then, just as mysteriously as it had started, the problem disappeared and the intensity and focus controls began working normally, as did the rest of the scope. At this stage, I should mention that my workbench is located in an outbuilding and is unheated. What's more, the night that I happened to be working on this scope was rather cold.

Past experience told me that I hadn't fixed the problem and that it would almost certainly reappear. Sure enough, when I turned the scope on the very next day (when it was several degrees warmer), the buzzing sound and the focus fault were again very much in evidence. I got a length of hose, held one end to my ear and placed the other end over every component around the high-voltage section to see if I could determine the source of the buzz but still no luck.

In desperation, I decided to turn off the lights in my workshop in the hope that, if it was an arcing problem, I could see the source. Initially, I looked around the high-voltage section on the main PCB but again drew a blank. And then, just as I was starting to walk back to the light switch, I noticed a small spark out of the corner of my eye. It was quite tiny and was located on the front-panel PCB – not where I had expected a fault to be.

In turned out that this sparking was coming from one of the terminals on the focus potentiometer. A quick look at the schematic confirmed that this terminal carried a high voltage, which explains why the front panel PCB was shielded with a clear plastic cover. Turning the focus and intensity controls made the spark change, so I had found the problem.

So why had the problem disappeared the night before? Well, as I mentioned, it was a particularly cold night and the cold air, with its low humidity, was acting as a better insulator than before.

In the end, the problem came down to poor design. The clearance between the high-voltage tracks was very small; certainly not enough to support the several hundred volts present.

There was no conformal coating or any other method to improve the insulation. I applied a blob of epoxy over the area and after waiting for the epoxy to cure, gave it a test. The scope then worked fine, so that was another one out of the way.

Scope repair 3

Next on the list was a 60MHz Tektronix 2133 that I picked up a few years ago from a deceased estate. When I subsequently tested it, channel 1 worked OK but channel 2 didn't operate at all.

Since I had been on a roll with the other two scopes, I thought that I would now give this one a shot as well. This was a scope that I actually wanted to keep, as it would be a good supplement to my digital scope. So onto the bench it went.

I applied power and a trace appeared on the screen but then the power suddenly failed. In fact, when I checked everything out, the circuit breaker on my distribution panel had tripped. I reset the breaker and tried powering the scope on a number of times but the result was always the same – the breaker would trip after about 10 seconds.

This particular breaker has an earth leakage function and a separate flag to indicate when it has been tripped by an earth leakage fault. In this case though, it wasn't an earth leakage fault.

I did all the usual checks, including checking the resistance between the scope's Active and Neutral connections and the resistance between the supply rails and ground etc but couldn't find anything unusual. I then downloaded a schematic but this didn't give me any further clues as to the cause.

In desperation, I tried temporarily powering the scope via an isolation transformer with the Earth disconnected. Surprisingly, the scope now remained operational and there was no indication of any excessive current being drawn.

That led me to conclude that there must be a fault path to ground and the only element I could identify that could cause this problem was the enclosed line (mains) filter built into the scope. It took a great deal of effort to remove and replace this item as the original soldering was expertly done at the factory (what else would one expect from a Tektronix scope?). However, when I retested it, the fault was still there.

By now, I had run out of ideas as to what could be the cause and as I was going to keep this scope for myself, the option of just running it through an isolation transformer seemed to be the solution. After all, all the internal supplies are working and within specification. Still, it would have been nice to have found the problem.

Scope repair 4

I won't name the last scope that I tried to fix. It was one that I bought on price (a bad mistake) when I was desperate for a scope. As before, it was a 2-channel 20MHz scope of Chinese origin. When I opened up the case, I saw why it was so cheap. Most of the wiring is done via ribbon cable rather than via PCB tracks.

The problem with this scope was that, on power up, the trace would skip across the screen once and then disappear. The focus and intensity controls had no effect.

I quickly determined that neither the tube supply nor the focus supplies were anywhere near specification. These voltages, of which there are several, are derived from a switchmode power supply (SMPS), which is just a self-oscillating design with no regulation on the output side. Instead, the regulation occurs on the input side, where positive and negative regulators supply the switched side of the transformer primary.

In operation, these regulators were getting very hot and, in fact, were operating in current limit. And that ex-

Servicing Stories Wanted

Do you have any good servicing stories that you would like to share in The Serviceman column in Silicon Chip? If so, why not send those stories in to us? In doesn't matter what the story is about as long as it's in some way related to the electronics or electrical industries, to computers or even to car electronics.

We pay for all contributions published but please note that your material must be original. Send your contribution by email to: editor@siliconchip.com.au

Please be sure to include your full name and address details.

Battery-Powered Golf-Cart Repair

It's often said that golf is a good walk ruined, which is why some people choose to use a battery-powered golf cart. J. N. of Tauranga, NZ recently saved a customer the indignity of walking after that little white ball . . .

I'm a semi-retired electrical/electronic technician and being a keen golfer, I've let it be known that I'm prepared to troubleshoot and repair electric golf carts and trundlers. As a result, quite a few jobs come my way through our local club and I also often get referrals from battery retailers.

Recently, a retailer referred a customer who owned a 1998 Club Cart that was manufactured by Ingersol Rand. He duly arrived at my workshop and explained that his cart would not go and also that the batteries were probably flat. He had taken it to a garage but the mechanics had been unable to get it working. He also told me that he had purchased a new battery charger some two years before.

After assuring him that I would do my best for him, I set about checking the cart out. This particular model is the DS series and is powered by a 48V lead-acid battery bank running a shunt-wound motor. It has great power for any terrain and features dynamic braking.

In addition, the motor will act as a charger if the cart is free-running downhill. This particular manufacturer is the only one that provides a battery charger with the cart and this charger is controlled by an on-board computer mounted in the cart itself. All in all, it's a very well-made unit.

I began by testing all six of the 8V batteries and found that they were all in good condition, which indicated that the charger must be faulty. Sure enough, after plugging it in, there was no sign of any charging activity.

I then dismantled the charger and discovered that it was a switchmode type. Most of the on-board Mosfets and diodes had fused and the main PCB looked to be well past repair. Judging by the rust present on the screws holding it together, I suspect that moisture had found its way inside the unit, causing it to fail.

Fortunately, the owner had also brought in the original Club Cart charger, so I decided to see if this could be made to run again. However, when I checked out the cart's wiring, I discovered that someone had bypassed the on-board computer in order to get the unit working with the later replacement charger.

Usually, the encapsulated on-board computer has a FET to control the charging and if this fails the unit is not repairable. As a result, I have also carried out the same modification to bypass the computer on Club Carts myself.

I contacted the customer and explained that his replacement charger would be too costly to repair. I then told him that he could either buy a new charger or I could modify the original charger to make it operate automatically, this for about half the cost of a new charger. Not surprisingly, he opted to have the original charger modified.

The original charger is quite simple and uses a mains transformer with a centre-tapped secondary to drive a full-wave rectifier consisting of two diodes. It's normally operated when the on-board computer energises a 48V DC relay in the charger itself, to switch the incoming mains to the transformer.

Fortunately, I had a factory-made adjustable 10-60V DC voltage controlled switch in stock and having carried out this type of modification before, I had previously designed a suitable timer circuit for the unit. It used a CMOS 4060 4-stage counter IC to operate a second relay, to turn the charger off after a set time. This was to safeguard against the charger not turning off automatically if a faulty battery stopped the battery bank from reaching the fully-charged voltage.

Because there's not much spare room inside the charger, I had to relocate the internal 48V relay and install the voltage switch and timer in its place. The negative lead from the cart was connected to the NC contacts of the voltage switch and the timer's NC contacts to energise the original 48V relay. Now, as soon as the charger was connected to the cart, charging would take place until either the voltage switch or the timer operated.

I then tested the modified charger circuit and the batteries charged up nicely. However, nothing happened when I tried to take the cart for a test run, much to my frustration!

The owner had previously mentioned that the cart had been "playing up" for some time, either by suddenly stopping for no apparent reason or by "juddering" until it finally ceased working. I already had the wiring diagram for this model, so I set about checking the control wiring but this was OK. I then suspected that the main power solenoid contacts might be faulty. This solenoid is operated via a switch as soon as the accelerator pedal is pressed.

The solenoid was covered in dirt and dust, so I carefully cleaned this muck away and discovered that it looked rather strange. As a result, I disconnected the batteries and removed the solenoid. This revealed that it had been broken open at some time in the past and "repaired" by someone. It had then been very badly re-assembled, with pieces broken off, and held together with cable ties and some sort of glue.

No wonder the cart's owner had been having troubles!

I always replace a faulty solenoid since repairs rarely last for long. The cart's owner is now a happy golfer again.

plained why the secondary voltages were nonexistent.

Having obtained a circuit diagram online, I spent an hour or two trying to diagnose the source of the problem. The only conclusion I could reach was that the SMPS transformer had developed a shorted turn.

Out of curiosity, I checked out the prices this type of scope was fetching on eBay and the answer was not much. So the question was, should I try and obtain a transformer and replace it? The vendor didn't have any spare parts for this model and I quickly came to the conclusion that the necessary investment in parts and time wasn't warranted. Instead, the better course of action was to remove a handful of useful parts and scrap the rest.

It's a shame when a number of factors come together and force this decision. My first mistake was to buy cheap because I ended up with an inferior product that failed quickly. Secondly, the vendor provides no spare parts back-up and so the scope is as good as junk if one of those specialised parts fails.

There also seems to be little interest in secondhand scopes unless they are a quality brand. This goes back to the first point, where buying cheap usually isn't the best decision in the long run

The last scope I bought was a Rigol DS1052e and it's the best scope purchase that I have ever made. It's been completely reliable and is easy to use. It was a bit of a stretch (for me) to buy it but it's now my workhorse. **SC**

This Precision Turntable Driver will power belt-drive or idler driven turntables with 230VAC at 50Hz or 115VAC at 60Hz. As a bonus, the turntable can then provide a pitch adjustment range of ±12% which is great for music teaching applications. It also allows you to adjust the music speed to obtain the correct number of beats to the minute for dancing applications.

OK so it does all the above but why would you want it?

The most obvious reason is if you have an imported American turntable which needs to run from a 115VAC 60Hz supply.

That's a real problem in Australia and New Zealand where we have a 230VAC 50Hz mains supply.

Sure, you could get a 230V to 115VAC step-down transformer to provide the correct drive voltage but at 50Hz the turntable would run almost 17% slow and the motor would tend to overheat, making it unusable. So that's reason number 1.

The second reason to consider building this Precision Turntable Driver is if you travel around the countryside and want to play records in your caravan or motor home when you are away from the 230VAC 50Hz supply.

Sure, you may have a 12V to 230VAC inverter but there is no guarantee that its frequency will be reasonably close to 50Hz, which can mean that the turntable may run noticeably fast or slow.

Realistically, most people are rela-

tively insensitive to pitch errors but small inverters can not only be incorrect in their frequency but can also change frequency according to the load. The same effect can occur with portable petrol generators.

Sinewave and modified square wave inverters can also have quite a high proportion of buzz and hash in their outputs – and this can be picked up by the very sensitive preamplifier needed for a magnetic cartridge.

Thirdly, while it is fairly common for "better" CD players to have a pitch control, which is useful for music and singing teachers, a variable speed facility on a turntable is (was) generally only available on expensive direct-drive models.

Now, with our Precision Turntable Driver, you can have this facility on any belt-drive or idler drive turntable.

And if you are the disc jockey running dances, having a variable speed facility on a turntable is also very useful to obtain the correct beats per minute. For example, music for a Viennese Waltz should be at around 160 beats per minute; quite fast.

Finally, we should note that if you have an old belt-drive or idler-drive turntable, its speed may not be exactly correct, when checked with a strobe disc and our Turntable Strobe (see SILICON CHIP, December 2015).

Unless you can perceive perfect pitch, any small error in speed is simply academic but you do have the ability to make it *precisely* correct via the fine speed adjustments available on the Turntable Driver.

The Turntable Driver can be run from a 15V 2A DC supply or from a 12V battery. The battery options means that you can use it anywhere where you don't have a mains supply.

With a 15V DC supply, the output will be close to 220VAC, or if you are operating a 110-120VAC powered turntable, the output will be close to 110V.

If you run from a 12V DC, supply, the output will be less (at around 180VAC) but most turntable motors seem to run quite well at this lower voltage.

The Precision Turntable Driver is housed in a rugged diecast aluminium case with a DC socket, On/Off toggle switch and a red power LED at one end. At the other end is the 3-pin mains output socket.

If you want to use the speed adjust facility (without opening the case), you will also need to mount three small momentary-contact buttons on the lid.

Features

- Can be used with a 12 to 15V DC supply or a 12V battery
- 230VAC or 115VAC (nominal) sinewave output
- 50Hz or 60Hz output frequency
- Crystal accuracy
- Pitch control (frequency adjustment)

Block Diagram

Fig.1 shows the block diagram for the Turntable Motor Driver. A 5-bit digital to analog (D-to-A) converter is used to generate a 32-step sine wave signal. This is shown as the yellow trace in the screen grab, Scope1, and it is close to 5V peak-to-peak.

The waveform is then amplified and filtered by op amp IC2a and the result is the green trace, with an amplitude of just over 14V peak-to-peak.

The signal is then fed to op amp IC2b which functions as a 12dB/octave low-pass filter to remove the 32 steps and produce a smooth sinewave.

This can be seen in screen grab Scope2 as the yellow trace. The

The Precision Turntable Driver is housed in a diecast case, with a flush-mount mains outlet accepting a standard 250VAC mains plug. Note the way the transformer is mounted at 45° to the PCB to allow it to fit in the case.

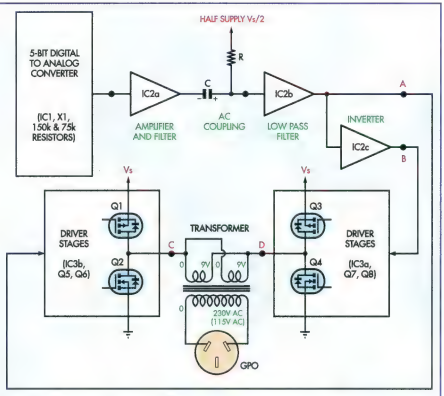


Fig.1: the Precision Turntable Driver circuit generates a clean sinewave signal and feeds it to a Class B amplifier driving a step-up transformer to produce 220VAC or 115VAC.

waveform is then inverted in op amp IC2c, as shown in green trace.

The two signals are then buffered by complementary Mosfet driver stages which provide the high current drive for the transformer. The resultant drive signals are depicted in the yellow and green traces in screen grab Scope3.

The drive signal across the transformer primary windings is shown in the mauve trace, which is the difference (MATH function) of the two buffered drive signals. Its amplitude is a little less than twice that of the drive signals.

The 9V primary windings of the transformer are connected in parallel to be driven by the Mosfet buffer stages. The transformer steps up the output to drive the turntable.

The secondary of the transformer has two 115V windings, which are connected in series for a nominal 230VAC output (for turntables which require a 50Hz mains supply) and in parallel for a nominal 115VAC output (for turntables which require a 60Hz mains supply).

Losses in the transformer mean that it does not deliver the full 115VAC output across each winding, even though the 9V windings are driven at more than 10VAC.

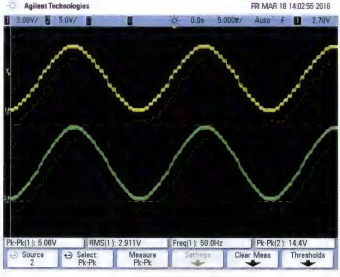
The (unloaded) output waveform from the transformer is shown in Scope4. The actual voltage delivered to the turntable motor will depend on the DC supply voltage fed to the circuit and the loading of the motor.

Circuit details

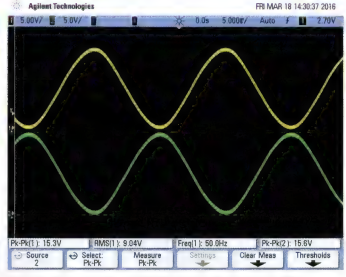
The complete circuit of the Precision Turntable Driver is shown overleaf (Fig.2). It is split into two sections: on the left (top) is the Power Supply and Signal Generator while the Mosfet output stages and step-up transformer are on the right (bottom).

Referring now to the power supply section, IC1 (a PIC16F88 microcontroller) is used to generate the 50Hz or 60Hz sinewave.

IC1 uses a 20MHz crystal for its timebase and the internal software program operates at a 5MHz rate. Jump-



Scope1: The stepped sinewave from the 5-bit DAC is shown in the yellow trace. The steps are smoothed out by the first op amp low-pass filter and the result is the green trace.



Scope2: The smooth waveform from the low pass filter (yellow trace) is inverted by op amp IC2c to produce the complementary waveform shown in the green trace.

er link JP1 sets the output frequency: with the jumper open it's 50Hz and with a jumper shunt inserted it's 60Hz.

Momentary-contact switches S3 and S4 provide the up and down frequency adjustment. The frequency is changed in 0.02Hz steps at a rate of four per second while a switch is held pressed. Pressing default switch (S2) returns the frequency to the precise 50Hz or 60Hz setting (depending on the state of JP1).

All the inputs associated with JP1, S2, S3 and S4 include separate internal pull-ups that keep the inputs high (at 5V). The inputs are pulled low (0V) when there is a shorting link in JP1 or when a switch is pressed.

S2-S4 can be mounted on the lid via flying leads from CON2 if you wish to be able to adjust the speed without opening the box. In this case, the internal S2-S4 can be omitted.

Digital-to-analog conversion

Five outputs from IC1, RA0 to RA5, produce square wave signals at multiples of the desired output frequency. These outputs are fed to the 5-bit digital to analog converter (DAC) which is actually a standard R/2R resistor ladder (comprising 150kΩ and 75kΩ resistors). This generates the 32-step sinewave signal.

The R/2R resistor ladder makes a cheap DAC and five bits is about the maximum number that can be used when only 1% resistors are used. It is quite sufficient for this application.

The DAC output is filtered with a 1nF capacitor to remove switching glitches. The resulting 5V sine wave is amplified using IC2a which is one quarter of an LMC6484AIN quad rail-to-rail op amp.

Trimpot VR1 is used to adjust the output level to produce the maximum undistorted sinewave signal.

Following this, the signal from IC2a is AC-coupled with a 10μF capacitor and is now referenced via 10kΩ resistor to half supply ($V_{CC}/2$) which is derived with two 10kΩ resistors connected across the V_{CC} supply and then buffered using op amp IC2d. Note that the supply to IC2 (and IC3) comes via a 10Ω resistor and is clamped to 15V using zener diode ZD1. This is to protect the op amps that are rated for a maximum rail voltage of 16V. This clamped rail is marked V_{CC}'.

IC2b and its associated resistors and capacitors form a 2-pole Sallen-Key low-pass filter that rolls off above 160Hz at 12dB/octave.

The filter only affects the high frequency components of the 32-step generated sinewave which are multiples of 32 x 50Hz or 1.6kHz (or 32 x 60Hz or 1.92kHz).

IC2b's output is then inverted by op amp IC2c to produce a complementary waveform (ie, 180° out of phase).

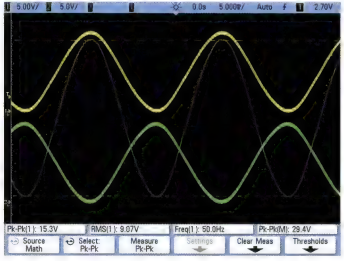
Transformer drive circuit

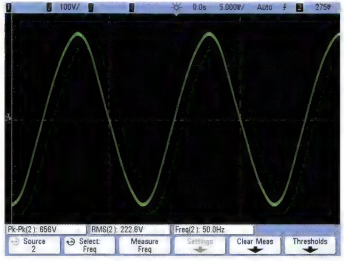
We need complementary drive signals for the transformer drive circuit which are shown in Fig.2 (labelled "A" and "B"). These signals are fed to non-inverting buffer stages IC3a and IC3b which in turn are connected to the complementary output stages.

Let's just describe the lefthand side of the power supply circuit whereby IC3b drives complementary transistors

Specifications

- Rating: 20W @ 220VAC or 110VAC (nominal)
- Input Supply: 12-15VDC at 2A
- Output waveform: Sinewave
- Output Voltage: 220VAC or 110VAC with a 15V supply
- Output regulation: 9% from no load to 15W
- Frequency accuracy: ±50 ppm (ie, ±0.005%)
- Pitch control: ±12%
- Frequency adjustment for 50Hz: 41.5Hz to 56Hz in approximately 0.02Hz steps
- Frequency adjustment for 60Hz: 50Hz to 67.2Hz in approximately 0.02Hz steps
- Default button: Restores the output frequency (JP1) setting to 50Hz or 60Hz





Scope3: the complementary sinewave signals from the Mosfet Class-B amplifier stages are effectively added to drive the transformer primaries. Its amplitude is the sum of the two signals (mauve trace).

Scope4: the unloaded output from the two 115VAC transformer windings connected in series. It is 222.6VAC or 656V peak-to peak. Note that this signal is much cleaner than the normal mains supply in homes, offices and factories.

Q5 & Q6, followed by complementary Mosfets Q1 & Q2. Q1 is an IRF9540 P-channel Mosfet while Q2 is an IRF540 N-channel type. The righthand side of the circuit is identical.

These stages operate in the same way as a Class-B audio amplifier and can simply be regarded as a unity-gain buffer.

More particularly, just as in a Class-B output stage, there is no quiescent current which means that it does produce some crossover distortion and while no-one will ever hear that crossover distortion we have incorporated biasing to minimise it.

The biasing is provided by the two diodes (D3 & D4) between the bases of transistors Q5 and Q6, with the current through the diodes provide by the 22kΩ resistor from Vcc. This current is about 300mA or so and the resultant bias voltage between the bases of Q5 & Q6 is insufficient (at around 1.1V in total) to cause them to conduct. However, that small amount of bias is enough to provide a significant reduction in crossover distortion but not enough to eliminate it.

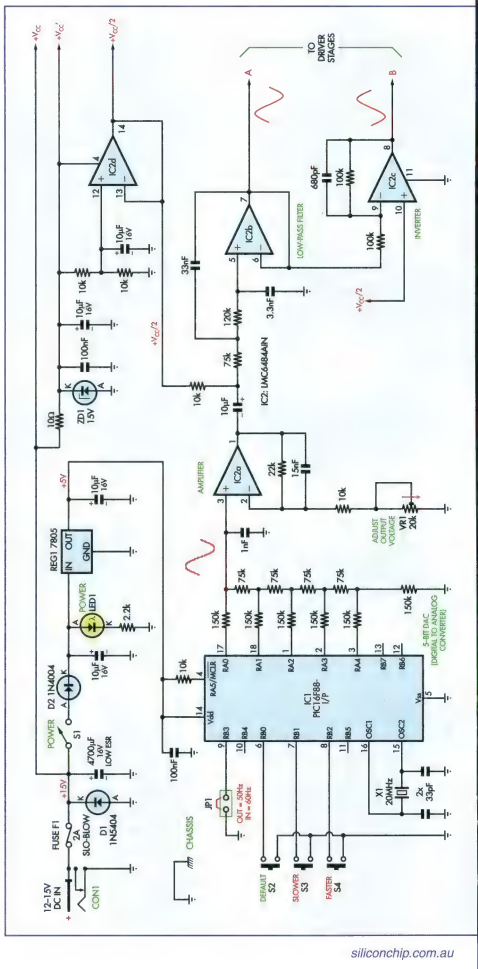
Why do we care? It is simply because the crossover distortion was causing significant inflections in the output waveform on the secondary side of the transformer and we judged it worthwhile to minimise it.

A 1.5nF capacitor between ground and the tied together transistor bases is included to reduce the rate at which the transistors can switch on and off. This prevents high frequency instability in the stage.

So we have the complementary signals at A & B being fed through the Class-B output stages and then connected to the paralleled 9V windings of the transformer. The actual maximum undistorted drive voltage from each Class-B output stage, assuming Vcc is 15V DC, is close to 5.1V RMS (14.43V peak-to-peak) and that gives a total AC voltage across the 9V windings of 10.2V.

The two 115V windings of the transformer are connected in series to provide a nominal 230VAC output (for turntables that require a 50Hz supply). For turntables that require a 60Hz 110VAC supply, the two 115V windings are connected in parallel rather than in series.

Because the transformer is a highly inductive load, especially when it is unloaded, its primary current lags the



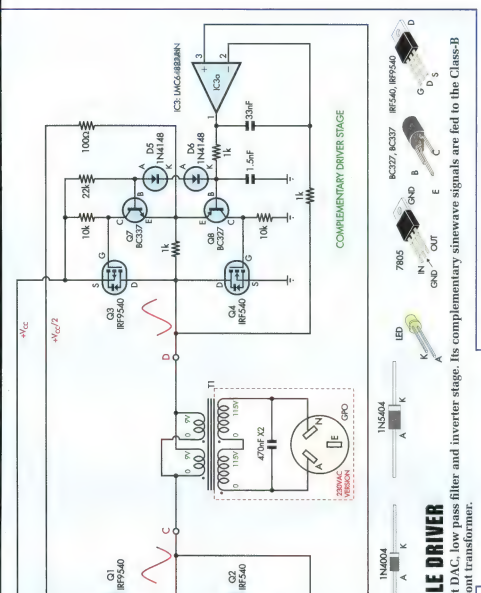


Fig.2: the top section of the circuit shows the micro and 5-bit DAC, low pass filter and inverter stage. Its complementary sinewave signals are fed to the Class-B output stages shown immediately above. Note the back-to-front transformer.

voltage by almost 90° and this would cause substantial heating of the Mosfets. This "power factor" problem is corrected by the 470nF (or 2.2µF for 115VAC) capacitor corrected across the transformer output.

Assembly procedure

The Precision Turntable Driver is built on a PCB (coded 04104161) measuring 84.5 x 112mm. It is housed in a diecast box that measures 171 x 121 x 55mm. The board is designed to be mounted on two of the integral mounts within the box and the outline of the PCB is shaped so that it fits neatly inside it.

Fig.3 shows the parts layout on the PCB. Assembly can begin with installation of the resistors, using the resistor colour code table as a guide. It is a good idea to also use a DMM to check each value as it is installed, as the colours can sometimes be hard to read or close to each other.

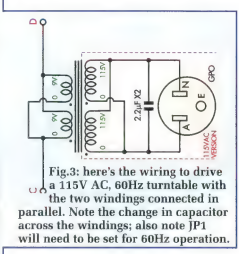


Fig.3: here's the wiring to drive a 115V AC, 60Hz turntable with the two windings connected in parallel. Note the change in capacitor across the windings; also note JP1 will need to be set for 60Hz operation.

Follow this by installing diodes D1 to D6 and zener diode ZD1. These must be mounted with the orientation shown.

Install IC1's socket next, followed by IC2 & IC3. Check that the orientation is correct before soldering each in place. Then install 20kΩ trimpot VR1 (it may be marked as 203). Switches S1 to S4 can be installed now along with the DC socket (CON1). Note our earlier comments about S2-S4.

Install Q5, Q6, Q7 and Q8, making sure Q5 and Q7 are BC337s and Q6 and Q8 BC327s. Leave Mosfets Q1 -Q4 off for the moment.

When installing the fuse clips, they must go in with their retaining tabs toward the outside ends, otherwise you will not be able to fit the fuse later on.

Better still, clip the fuse into the fuse clips first before installing the clips into the PCB holes.

Next, install the capacitors, ensuring the electrolytic types are placed with the correct polarity.

Now place Mosfets Q1, Q2, Q3 & Q4, taking care to fit the correct Mosfet in each location. These are positioned so that the mounting hole centre in each tab is about 22mm above the PCB. In every case, the metal tab must go towards the outside edge of the board.

The LED is mounted so that it can protrude through a hole in the end of the box. The leads are inserted with the longer anode (A) lead oriented as shown. If bent over, the LED can be set about 5mm above the PC board.

Connect a short (20mm) length of wire to the GND terminal on the PCB and terminate the other end to a solder lug.

Also solder two 50mm lengths of wire to the 0V and 9V pads ready for connection to the transformer.

Case drilling

Use the drilling template in Fig.5 to mark out and drill the holes for the power switch S1, LED1, the DC socket hole and earth screw at one end of the case and the surface mounted mains AC socket at the opposite end.

The larger hole for the mains socket can be drilled out using a series of small holes around the perimeter and then after knocking the inside piece out, filing to shape.

Place the PCB inside the case inserting the switch(es) and LED into their holes. Mark out the hole positions for the two PCB mounting positions that require 9mm stand-offs and orient the transformer diagonally as shown in the photos and diagram and mark out the mounting hole positions.

Drill out the holes for the stand-offs to 3mm in diameter and drill out the transformer mounting holes at 4mm in diameter.

Place the PCB in position, temporarily mounting this on the integral stand-offs in the box and on the 9mm spacers. Then mark the positions for Q1, Q2, Q3 and Q4 by marking where the metal tab holes of each are located when held against the side of the box.

Remove the board and drill these mounting holes to 3mm, then use an oversize drill to remove any metal swarf so that the area around each hole is perfectly smooth.

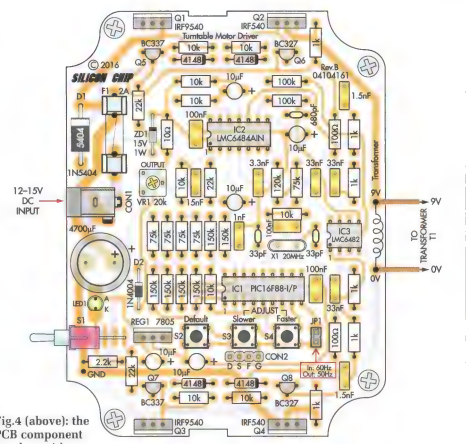
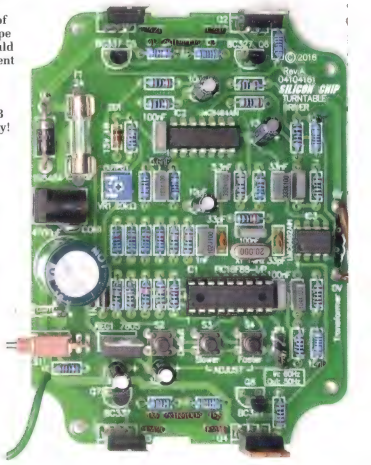


Fig.4 (above): the PCB component overlay, with a matching same-size photo below. The photo is actually of an earlier prototype board so there could be minor component differences compared to the PCB above. If in doubt, use the PCB component overlay!



Parts List – Precision Turntable Driver

1 PCB coded 04104161, 84.5 x 112mm
1 panel label 158 x 95mm ***(download from siliconchip.com.au)***
1 diecast box 171 x 121 x 55 (Jaycar HB-5046)
1 20VA mains transformer 50/60Hz 2 x 115VAC, 2 x 9VAC (RS Components 504-274)
1 transformer terminal shroud (RS Components 504-004)
1 250VAC mains panel socket, flush-mounting (Altronics P 8241 or P 8243, Jaycar PS-4094)
1 15VDC 2A supply (preferably a linear supply) or plugpack (or 12VDC with reduced output) or suitable 12V battery
1 DC socket, PC mount with 2.1 or 2.5mm centre pin to suit plugpack or supply lead DC plug
3 SPST micro switches (~3-4mm actuator) [for internal mounting] (Jaycar SP-0602, Altronics S 1120) (S1-S3) ***OR***
3 SPST momentary contact switches [for on-lid mounting] (Jaycar SP-0710/0711; Altronics S1060/1071A or similar)
1 SPDT PCB mount toggle switch (Altronics S 1421 or similar; S1)
1 2-pin header with jumper shunt
1 20MHz 50ppm (or less) crystal (X1)
1 M205 2A slow blow fuse (F1)
2 M205 PCB mount fuse clips
1 18-pin IC socket
4 rubber feet
2 M3 tapped x 9mm spacers
2 M4 nuts
2 M4 x 10mm machine screws (countersunk or pan head)
2 M3 x 6mm machine screws (countersunk or pan head)
2 M3 x 6mm machine screws
5 M3 x 10mm machine screws
5 M3 nuts
1 star washer for M3 screw
1 large solder lug
4 TO-220 insulating bushes
4 TO-220 silicone washers
1 20mm diameter x 50mm heatshrink tubing
1 20mm length of green or green/yellow 7.5A mains rated wire
1 500mm length of brown 7.5A mains rated wire
1 100mm length of blue 7.5A mains rated wire
4 100mm cable ties

Semiconductors

1 PIC16F88-I/P microcontroller programmed with 0410416A.HEX (IC1)
1 LMC6484AIN quad rail to rail op amp (IC2)
1 LMC6482AIN dual rail to rail op amp (IC3)
1 7805 5V regulator (REG1)
2 IRF9540 P channel Mosfets (Q1,Q3)
2 IRF540 N channel Mosfets (Q2,Q4)
2 BC337 NPN transistors (Q5,Q7)
2 BC327 PNP transistors (Q6,Q8)
1 3mm red LED (LED1)
1 15V 1W zener diode (ZD1)
1 1N5404 3A diode (D1)
1 1N4004 1A diode (D2)
4 1N4148 diodes (D3 - D6)

Capacitors

1 4700µF 16V low ESR electrolytic
5 10µF 16V electrolytic
1 470nF 275VAC X2 class MKP (polypropylene) for 230VAC output
(1 x 2.2µF X2 class polypropylene for 115VAC output)
3 100nF MKT polyester
3 33nF MKT polyester
1 15nF MKT polyester
2 1.5nF MKT polyester
1 3.3nF MKT polyester
1 1nF MKT polyester
1 680pF ceramic
2 33pF ceramic

Resistors (1%, 0.5W; # = metal film)

6 150kΩ #	1 120kΩ	2 100kΩ	5 75kΩ #	3 22kΩ
9 10kΩ	1 2.2kΩ	6 1kΩ	2 100Ω	1 10Ω

1 20kΩ miniature horizontal mount trimpot (VR1)

This is necessary to prevent punch-though of the insulating washer.

Reinsert the board into the case. Mount the transformer using M4 screws and nuts and mount the PCB using the screws supplied with the enclosure for the two mounting points in the corners.

The stand-offs are secured to the base of the case using countersunk M3 x 6mm screws (or machine screws) and machine screws (M3 x 6mm) to secure the PCB.

Then attach the TO-220 devices to the sides of the case as shown in Fig.7, using the M3 x 10mm screws. Note that it is necessary to isolate each device tab from the case using an insulating washer and insulating bush.

Once they have been installed, use a digital multimeter on a low Ohms range to confirm that the metal tabs are indeed isolated from the metal case. If a low resistance reading is measured, check that the silicone washer for that particular TO-220 device has not been punctured and that the insulation bush is not damaged.

Also connect the earth lug to the case using an M3 x 10mm screw, star

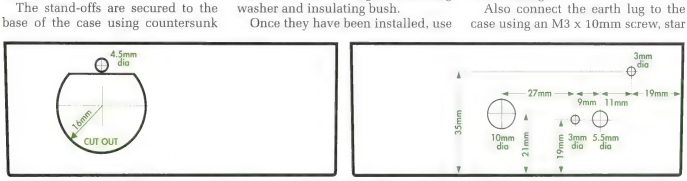


Fig.5: drilling details for the two ends of the case; the left is for the flush-mounting 250VAC mains socket and the right is for the switch, LED and DC socket. Additional holes will need to be drilled in the lid to accommodate the three speed switches.

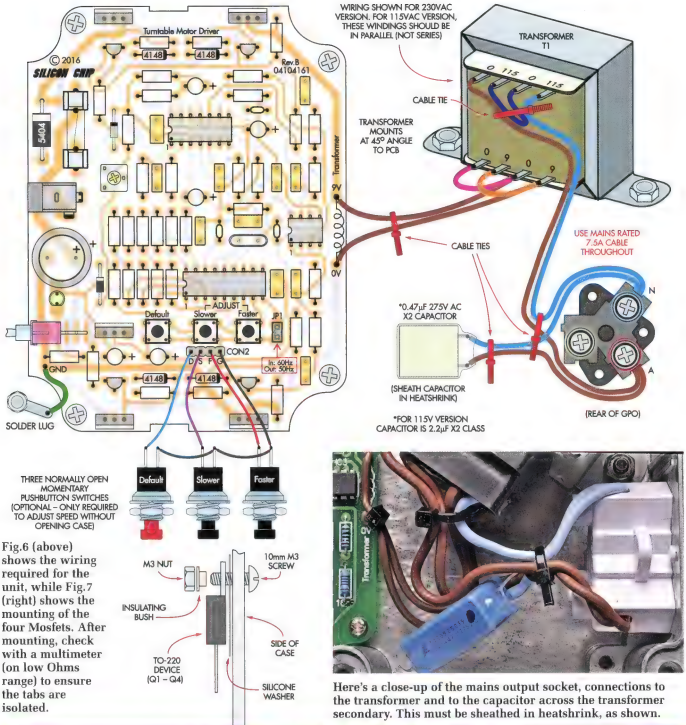


Fig.6 (above) shows the wiring required for the unit, while Fig.7 (right) shows the mounting of the four Mosfets. After mounting, check with a multimeter (on low Ohms range) to ensure the tabs are isolated.

Here's a close-up of the mains output socket, connections to the transformer and to the capacitor across the transformer secondary. This must be sheathed in heatshrink, as shown.

Resistor Colour Codes

	Qty.	Value	4-Band Code (1%)	5-Band Code (1%)
❑	6	150kΩ	brown green yellow brown	brown green black orange brown
❑	1	120kΩ	brown red yellow brown	brown red black orange brown
❑	2	100kΩ	brown black yellow brown	brown black black orange brown
❑	5	75kΩ	violet green orange brown	violet green black red brown
❑	3	22kΩ	red red orange brown	red red black red brown
❑	9	10kΩ	brown black orange brown	brown black black red brown
❑	1	2.2kΩ	red red red brown	red red black brown brown
❑	6	1kΩ	brown black red brown	brown black black brown brown
❑	2	100Ω	brown black brown brown	brown black black black brown
❑	1	10Ω	brown black black brown	brown black black gold brown

washer and nut. The adhesive rubber feet can now be attached.

Wiring it up

Follow the wiring diagram of Fig.6 to connect up the transformer and GPO. Make sure 250VAC mains-rated wire is used and you must use the terminal shroud for the high voltage terminals (at the two 0-115V winding connections) so these are covered over.

Wire the 115V windings in series for 230VAC and in parallel for 115V. Note the different capacitor value connected across the mains for the 230VAC (470nF X2) and 115V (2.2µF X2) versions.

Two wires each connect to the Active and Neutral GPO terminals. One is from the transformer and the other from the mains-rated capacitor. The capacitor and wire connections are encased in some heatshrink tubing for insulation.

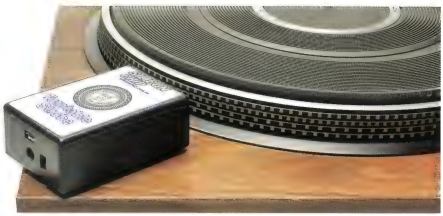
Note also that the Earth terminal on the GPO is left disconnected. The 230VAC wiring is anchored with cable ties as shown.

Set-up procedure

Ideally, the unit should be powered using a linear 15V DC 2A supply rather than a switchmode type. A linear supply is one where the mains voltage is stepped down using a 50Hz transformer and is then rectified, filtered and regulated to 15V.

This type of supply will avoid the injection of switching hash into sensitive magnetic cartridge signal leads.

Insert the slow-blow 2A fuse and apply power. Check that the voltage between pins 5 and 14 of the IC1 socket is close to 5V. Anywhere between 4.85 and 5.15V is OK. Switch off power and wait for the voltage on the IC socket to drop to below 1V and insert the programmed PIC16F88 into the socket, taking care to orient it correctly.



The Turntable Strobe, featured in the December 2015 issue, is perfect for ensuring accurate speed with the Precision Turntable Driver. If your platter doesn't have strobe markings (as this one does) a Strobe Disc, suitable for both 50Hz and 60Hz, is available from the Silicon Chip Online Shop for $10.00 (see below) (www.siliconchip.com.au/shop/19/3273)

Trimpot VR1 needs to be adjusted to give the maximum undistorted sine-wave output. The ideal way to do this is to use an oscilloscope to monitor the waveform.

If you do not have access to a scope and assuming that the DC supply is 15V, adjust trimpot VR1 to deliver 10.2V AC across the primary windings of the transformer.

If you are using a 12V battery, adjust trimpot VR1 to deliver 8.2V to the transformer primary.

When connecting up the turntable to the Turntable Motor Driver use the normal practice of connecting the turntable Earth wire back to the amplifier Earth terminal to minimise hum and noise.

The case of the Turntable Motor Driver does not need to be connected to mains Earth.

Setting the turntable speed

As mentioned, you can adjust the turntable speed using the faster or slower switches.

For an exact speed setting, you will need to monitor the turntable speed using the turntable strobe and a strobe disc (see the article published in December 2015 entitled *Check Turntable Speed With This White LED Strobe*). Adjust the speed so the strobe markings appear stationary.

Note that, depending on the power rating of the turntable, the DC input voltage and the ambient temperature, the case of Precision Turntable Driver will become warm after a few hours use.

This is normal and to be expected since the drive circuitry is linear and its efficiency is only about 50%. SC

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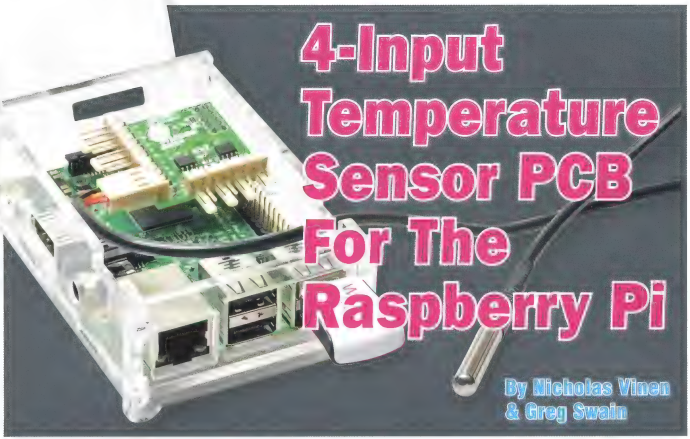


4-Input Temperature Sensor PCB For The Raspberry Pi

By Nicholas Vinen & Greg Swain

This simple PCB plugs directly into your Raspberry Pi's GPIO port and makes it easy to connect up to four Dallas DS18B20 1-Wire digital temperature sensors in parallel. As a bonus, it features four matching outputs that can either be toggled or momentarily activated in response to temperature; you just enter the trigger values into the software.

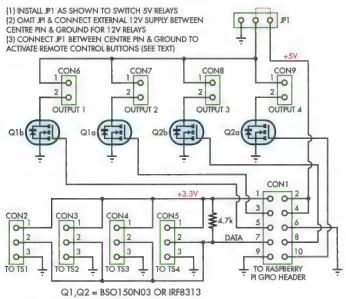


Fig.1: the circuit connects temperature sensors TS1-TS4 in parallel via CON2-CON5, while Q1a, Q1b, Q2a & Q2b switch outputs 1-4 in response to the temperature readings.

IN THE March 2016 issue, we described how to connect a Dallas DS18B20 digital temperature sensor to a Raspberry Pi (RPi) computer and showed how the readings could be accessed over the internet. Connecting a single device is easy; just wire its three leads to 1-way header sockets and plug these into the relevant pins on the RPi's GPIO port. It's then just a matter of connecting a 4.7kΩ pull-up resistor between the data line and the +3.3V supply and firing up the software to retrieve the readings.

Each DS18B20 has a unique 64-bit serial identification code. The software presented in March 2016 scans the **/sys/bus/w1/devices** folder to detect the sensor(s) and adds each device it finds to an array. It then interrogates the sensors and lists the readings.

In addition, the software allows you to assign a useful name to each sensor, such as "indoor1" or "outdoor" etc, so that the temperature reading from each sensor is displayed after its name.

The fact that each device has a unique identification code also allows multiple DS18B20s to function on the same 1-Wire bus. If you want

Fig.2: follow this parts layout diagram and photos to build the unit. Make sure that Q1 & Q2 are orientated correctly and note that CON1 is mounted on the underside of the PCB. The circuit and text describe the linking options for JP1.

to use multiple sensors, it's just a matter of connecting them in parallel, with a 4.7kΩ pull-up resistor shared between them (no need to add extra resistors).

Connecting multiple sensors

Connecting one DS18B20 to the RPi might be easy but it gets rather fiddly if you want to connect two or more devices. That's where this little PCB comes in; it plugs into one end of the RPi's GPIO and lets you connect up to four DS18B20 sensors simply by plugging them into 3-way polarised headers.

All you have to do is connect each sensor to a matching header socket as shown in an accompanying photo and the rest is easy.

Mosfet ouputs

As well as making it simple to connect multiple sensors, the PCB also includes two dual-Mosfet IC packages, to provide four switched outputs. Each output can be momentarily toggled or latched on or off when the temperature readings from any sensor or combination of sensors reaches preset trigger levels.

Circuit details

Fig.1 shows the circuit details. Polarised pin headers CON2-CON5 accept the connections from the DS18B20 sensors. In each case, pin 1 goes to the +3.3V rail (derived from the RPi's GPIO port), pin 2 is for data and pin 3 is connected to ground (pin 9 on CON1). The 4.7kΩ pull-up resistor is connected between the commoned data pins and the +3.3V rail.

CON1 plugs into pins 1-10 of the RPi's GPIO port. As shown, the data line goes to pin 7 of CON1 and this in turn connects to pin 7 (GPIO4) on the RPi.

N-channel Mosfets Q1a, Q1b, Q2a & Q2b provide the optional output switching. Q1a is controlled by GPIO2 on the RPi, Q1b by GPIO3, Q2a by GPIO15 and Q2b by GPIO14. Each Mosfet turns on when its corresponding GPIO pin goes high under software control (see below).

By installing link JP1 as shown, the outputs can be used to switch 5V relays. Alternatively, by deleting JP1 and feeding 12V from an external supply between the middle pin of the JP1 header and ground, the Mosfets can switch 12V relays.

Note that, at boot, GPIO2 & GPIO3 are high by default, while GPIO15 & GPIO14 are low. This means that, by default, Q1a & Q1b (output #1 & output #2) are on, while Q2a & Q2b (output #3 & output #4) are off.

Yet another option is to use Q2a and Q2b to switch two buttons on a remote control. In this case, jumper JP1 is installed between the middle pin and ground. The remote control buttons are then connected to output #3 and/or output #4, making sure that the ground side of each button goes to ground (now pin 1 on CON8 & CON9) on the PCB.

Building the PCB

The circuit is built on a small PCB coded 24104161 and measuring 31 x 33.5mm. Fig.2 shows the assembly details.

Begin by installing the 4.7kΩ surface mount resistor. That's done by applying a small amount of solder to one of its pads, then remelting the solder while you slide the device into position using tweezers. The other end is then soldered, after which you can go back and refresh the original joint.

The Parts Required

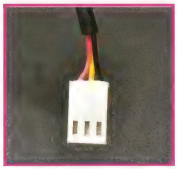
1 double-sided PCB, code 24104161, 31 x 33.5mm
2 BSO150N03 dual N-channel Mosfets, or use IRF8313
1 4.7kΩ resistor (1%, SMD 2012/0805)

Connectors & spacer

1 2 x 5-way PCB-mount female header (or cut down a 2 x 10-way header [eg, Altronics P5383] or use two 5 x 1 pin headers)
4 3-way, right-angle PCB-mount, polarised male pin headers, Altronics P5513 or Jaycar HM3423
4 3-way polarised female pin headers, Jaycar HM3403
4 2-way, right-angle PCB-mount, polarised male pin headers, Altronics P5512 or Jaycar
4 2-way polarised female pin headers, Jaycar HM3402
1 M3 x 6mm Nylon screw
1 M3 x 10mm tapped Nylon spacer
1 M3 Nylon washer

Where To Buy Parts

The PCB is available from the SILICON CHIP Online Shop. The dual Mosfets and 4.7kΩ SMD resistor are also available together as a short-form kit.



The temperature sensor PCB plugs directly into pins 1-10 of the RPi's GPIO port. Be sure to wire the DS18B20 temperature sensors to the header sockets as shown.

The two Mosfet chips go in next, taking care to ensure they are correctly orientated (pin 1 dot at top right). In each case, solder one of the end pins first, then check that the device is correctly aligned with its pads before soldering the remaining pins. Don't worry if you bridge two adjacent pins with solder; the excess solder can easily be removed using solder wick.

Next, install a link between +5V and the centre pad of JP1 if controlling 5V relays or leave this link out if you intend using an external supply to power 12V relays.

Alternatively, install a link between the centre pin of JP1 and ground if using outputs #3 and #4 to switch buttons on a remote control. **In that case, you also need to configure the software so that the outputs only go low momentarily (see notes in Fig.3 below).** If you later find that the Mosfets fail to activate the buttons, move the link back to the +5V position and use outputs #3 and #4 to activate the buttons via 5V reed relays or conventional 5V relays.

Connectors CON1-CON9 can now all go in. Note that CON1 is mounted on the underside of the PCB (see photo). Finally, fit an M3 x 10mm tapped Nylon spacer plus a Nylon washer to the underside of the PCB and secure these in place using an M3 x 6mm Nylon screw. This spacer keeps the PCB stable when it is fitted to the RPi's GPIO header.

Getting it going

Once the assembly is complete, the PCB can be installed by plugging its CON1 header into pins 1-10

Fig.3: Some Notes On Config.py

(a) You can base the status of an output on more than one sensor. For example:

```
def output3(temps):
    if (temps['indoor'] < 20 or temps['indoor'] > 35) and temps['outdoor'] > 30:
        return 'HIGH'
    else:
        return 'LOW'
```

or even:

```
def output3(temps):
    if temps['indoor'] > temps['outdoor'] + 3.5:
        return 'HIGH'
    else:
        return 'LOW'
```

(b) Rather than have an output switch high or low as long as given condition exists, you can have it briefly pulse high or low for a number of milliseconds or seconds. Simply do something like:

```
def output3(temps):
  if temps['indoor'] > 35:
     return 'HIGH:500ms'
  else
     return 'LOW'
```

You can use a suffix of either 'ms' or 's' (for milliseconds and seconds, respectively).

of the RPi's GPIO port. After that, it's just a matter of connecting one or more Dallas DS18B20 temperature sensors to female 3-way polarised headers and plugging them into the input connectors on the PCB. Make sure that the sensor's red wire goes to the "+" pin, the yellow or blue wire to the centre pin and the black wire to the "-" pin (see photo).

Note: if you previously fitted a 4.7kΩ pull-up resistor to the RPI's GPIO port, then this should be removed.

Setting up the software

STEP 1: connect a monitor , keyboard and mouse to your RPI (or log in using VNC – see January 2016).

STEP 2: update and upgrade the system (note: this step in most important, otherwise there's a chance the RPi will won't boot after you complete Step 8):

```
sudo apt-get update
sudo apt-get upgrade
sudo reboot
```

Note that this may be a lengthy process if it hasn't been done for some time.

STEP 3: launch the RPi's web browser, go to **www.siliconchip.com.au**, click Shop, select Software from the drop-list and left-click **RPiTempMon.zip**

The file will immediately download to the **/pi/Downloads** folder. Navigate to this folder in the file manager, then right-click the zip file to extract these four files: **dt-blob.dts**, **index.py**, **config.py** and **tempmon.py**

STEP 4: move the three **.py** files to **/var/www/html** as follows (note: overwrite any existing **index.py** file):

```
sudo mv /Downloads/index.py /var/www/html
sudo mv /Downloads/config.py /var/www/html
sudo mv /Downloads/tempmon.py /var/www/html
```

STEP 5: change ownership of the **index.py** file to **www-data**, as follows:

```
sudo chown www-data /var/www/html/index.py
```

STEP 6: set up the RPi to read the DS18B20 sensors and send temperature readings to a web-server as described in the March 2016 issue of SILICON CHIP (see the February 2016 issue for the web-server set-up details). Note that you have to add each DS18B20's ID to the **sensor_names** = line in the **index.py** file in **/var/www/html**; eg:

```
sensor_names = {"0115812a9fff": "indoor1", "011581aefaff": "indoor2"}
```

If you only need temperature readings and you don't need to switch the outputs, then that's all you need to do and you can go straight to Step 12 (ie, reboot the system).

Alternatively, if you want to trigger any of the outputs in reponse to temperature measurements, the following additional steps are necessary.

STEP 7: install Device Tree Compiler (DTC) on the RPi using the following command:

```
sudo apt-get install device-tree-compiler
```

Output States At Boot

At boot, Q1b & Q1a (outputs #1 and #2) are on by default and outputs Q2b & Q2a (outputs #3 and #4) are off. So use outputs #1 and/or #2 for tasks where you normally want the load to be switched on (or don't care) initially and #3 and/or #4 when the load should be off by default.

You can edit the .dts file to turn outputs #1 and #2 off initially. However, there may be a brief period where they are switched on immediately after power is applied, so it's safer to use outputs #3 and #4. The config.py file should be consistent with this convention (see our examples).

For further information on setting up the RPi's I/O pin states at boot, refer to:
https://www.raspberrypi.org/documentation/configuration/pin-configuration.md

In addition, the following link explains how to set the I/O pin states from Python:
http://raspi.tv/2014/rpi-gpio-quick-reference-updated-for-raspberry-pi-b

STEP 8: go to the **/home/pi/Downloads** folder and install **dt-blob.dts** using the following command:

```
sudo dtc -I dts -O dtb -o /boot/dt-blob.bin dt-blob.dts
```

This installs a file called **dt-blob.bin** in the **/boot** folder and sets up the GPIOs we're using as outputs at boot time – see the above panel. Note: delete this file, or change its name, if the system fails to reboot later on.

STEP 9: Edit **config.py** to customise it for your requirements. For example:

```
def output1(temps):
    return 'HIGH'

def output2(temps):
    return 'HIGH'

def output3(temps):
    if temps['indoor1'] < 20 or temps['indoor1'] > 27:
        return 'HIGH'
    else:
        return 'LOW'

def output4(temps):
    return 'LOW'
```

This example sets up output #3 (initially off at boot time) to switch on if the temperature of the "indoor1" sensor is below 20°C or above 27°C. Fig.3 on the facing page shows two more examples and also shows how to switch the outputs momentarily high or low (rather than have the outputs toggle)

STEP 10: run **python /var/www/html/tempmon.py** and check that it prints the temperature readings once per second. Check that the outputs switch on and off as the temperature varies, as expected. Press CTRL+C to terminate.

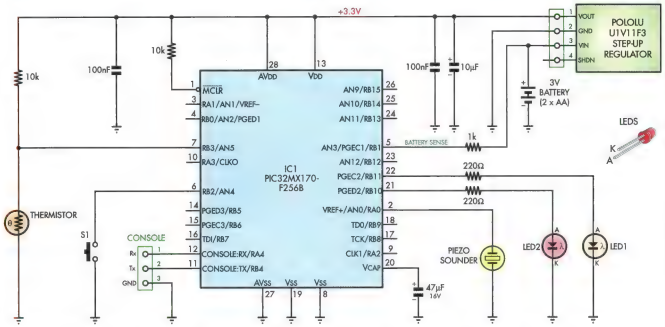
STEP11: edit **/etc/rc.local** and add the following line to the end, before the "exit 0" line:

```
python /var/www/html/tempmon.py > /dev/null &
```

STEP 12: reboot. **SC**

CIRCUIT NOTEBOOK

Interesting circuit ideas which we have checked but not built and tested. Contributions will be paid for at standard rates. All submissions should include full name, address & phone number.



Micromite-based stove left on reminder

This project was developed after failing to turn off a gas burner after use. That is all too easy to do and it can damage saucepans. The unit is mounted above the gas range to monitor the ambient temperature. When it detects a rapid rise in local temperature, it triggers the alarm.

When the over-temperature alarm is triggered, the following sequence occurs: every 10 seconds it flashes both LEDs. Every five minutes, it emits three short beeps. After two hours have elapsed, the beeps will be continuous and must be acknowledged by pressing the button.

If the temperature drops rapidly or the temperature reaches the pre-alarm value, the alarm condition resets. The object is for this to serve as a reminder and if cooking has been completed and a burner has been left on, the beeps will send you back to the kitchen to check, turn off the burner and reset the alarm.

The circuit consists of a Microchip PIC32MX170F256B microcontroller which monitors an NTC (negative temperature coefficient) thermistor and drives two LEDs and a piezo buzzer. The program runs in MMBasic. Power comes from two AA alkaline or NiMH cells which feed a boost regulator to produce the 3.3V supply rail. Battery life is estimated to be about six months. The battery voltage is monitored and a low battery is signalled audibly. Yellow LED1 indicates normal running and red LED2 indicates an alarm condition.

The micro is mostly in sleep mode, waking approximately every 10 seconds to measure and store the ambient temperature. During this sequence, the temperature delta and the direction of the change is recorded and compared with the two factors set in the firmware and dependent on the result, an Alarm or Reset condition may be generated.

The software is very responsive to temperature changes and will detect the smallest gas burner being ignited, usually within one or two sleep cycles, ie, within 20 seconds. The program will also attempt to determine when an alarm condition no longer exists, ie, no more heat sources, and reset the device. If this does not occur, pressing the reset button during a wake period will reset the device.

The device is housed in a small enclosure with the NTC sensor mounted externally on the end of a flexible probe.

The software, mm2Stove11.bas, can be downloaded from the SILICON CHIP website.

Michael Ogden,
Yarragon, Vic. ($80)

Circuit Ideas Wanted

Got an interesting original circuit that you have cleverly devised? We need it and will pay good money to feature it in the Circuit Notebook pages. We can pay you by electronic funds transfer, cheque (what are they?) or direct to your PayPal account. Or you can use the funds to purchase anything from the SILICON CHIP on-line shop, including PCBs and components, back issues, subscriptions or whatever. Email your circuit and descriptive text to editor@siliconchip.com.au

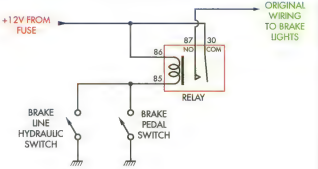
Relay circuit for cars with hydraulic brake switches

Many pre-1970 cars have hydraulic brake light switches and these are often unreliable or require a lot of force on the brake pedal to light the brake lamps because of high contact resistance.

The solution is to install a normally closed (NC) microswitch just above the brake pedal arm. The pedal arm rests against the switch button, breaking the circuit. The slightest downwards movement of the pedal allows the switch button to push out and close the circuit.

The mechanical switch and the original hydraulic switch were wired in parallel to operate a relay (eg, Jaycar SY-4068) and thence the brake lights.

This modification allows the brake lights to come on much earlier and requires almost no pedal force. All classic car owners should consider this safety upgrade.



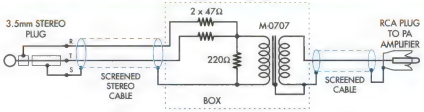
Keeping the look of a classic car is very important so the relay sits under some sound insulation and the original wiring has only been slightly re-routed so that it can be returned to original in the future if needed.

Dave Dobeson,
Berowra Heights, NSW. ($40)

Isolated line connection for laptop to amplifier

This circuit shows how to connect the audio output of a laptop to a PA amplifier or mixer without the possibility of an Earth loop through the power supply when the laptop is being charged. It should also result in less hum and buzz pick-up in the cable, which is especially useful if it's a long run. It uses an audio isolating transformer and a few other parts.

The transformer is an Altronics M0707 600Ω:600Ω type. It has a centre tap on one side but this is not used; simply insulate the black wire. The three resistors mix the stereo signal to mono which is then applied to the lefthand side of the transformer.



The signal is coupled to the right-hand side unchanged, however the galvanic isolation of the transformer allows the output signal to float relative to the input side and without a ground connection between the two sides, a ground loop can not form. Note that the transformer case is connected to the shield of the screened output cable for shielding.

Ross Weir,
Christchurch, NZ. ($30)

Test & label those plugpacks

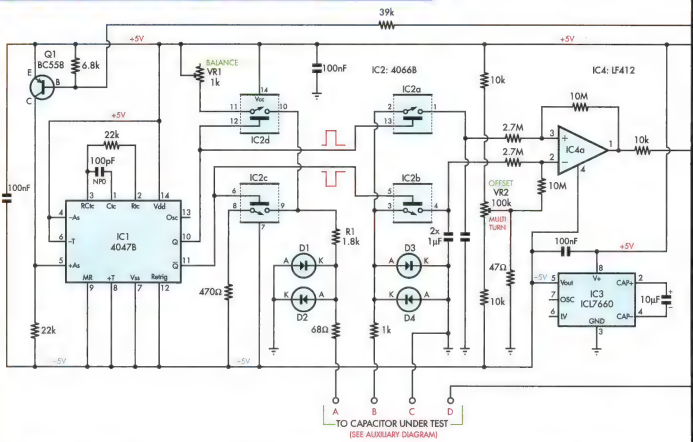
Do you have a collection of unused AC & DC plugpacks in boxes, cupboards and forgotten in other places? I did until recently. Everyone involved in electronics or computers seems to accumulate a collection of these over the years as the devices they once powered are replaced, fail or otherwise fall into disuse. But you keep the plugpacks, don't you? After all, you never know when a particular plugpack might come in handy for a particular job.

The other day I went looking for a 9V DC plugpack capable of delivering a few hundred milliamps. Yes, just dig around in the various places where you know you left some and you are sure to come up trumps. Well, think again. For a start, these beasties are often stored where the lighting is poor, their labelling is hard to read and they are inevitably tangled with others of their kind, making retrieval a pain.

The solution? Collect every unused plugpack you can find. Test each one to see that it is working, bind up its output lead with a twist-tie and label it clearly. Make sure that you can readily see whether each plugpack is AC or DC and that you have written down the current rating as well as the voltage and type (switchmode/linear).

Many recent model DC plugpacks are very compact switchmode types and they are desirable because they are very efficient, an advantage if they are to be used continuously in a standby application. But the older linear transformer types are also worth keeping, particularly for applications where switchmode hash would otherwise be a problem.

Leo Simpson,
Silicon Chip



ESR meter with LCD readout

This circuit enables you to measure the ESR (equivalent series resistance) of capacitors in and out of circuit and displays the result on an LCD. It's roughly based on Len Cox's design (Circuit Notebook, February 2005) but adds the micro and LCD panel, a buzzer and also includes a simpler capacitor driving arrangement.

As well as the LCD, a buzzer beeps a number of times to indicate the ESR or resistance value. For example, if the ESR is at least four and less than five ohms, the buzzer beeps four times. If the ESR is less than one ohm then the buzzer beeps every 50ms continuously, until the capacitor being measured is disconnected. This feature is added so that you don't have to look at the display every time you check an in-circuit capacitor, which speeds up the checking process.

The circuit also senses if the capacitor is shorted; in this case, the buzzer is silenced and the display shows the resistance value with the word "resistor" under it. This feature can also be used to measure low resistance values. If the capacitor isn't shorted, then the display shows the ESR value with the word "capacitor" below it. If the measured resistance is 10 Ohms or more, the display reads "over range".

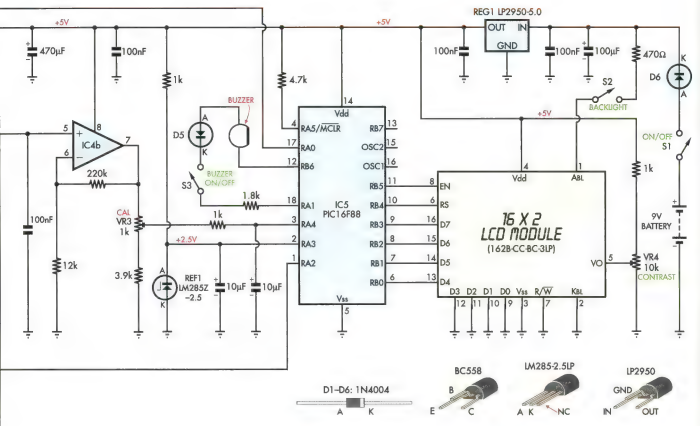
The buzzer can be switched off as well as the LCD backlighting to increase battery life.

In-circuit testing of capacitor ESR is useful because ESR tends to increase as electrolytic capacitors age and if it becomes too high, the equipment fails. Thus this unit can be used to identify the culprit(s) so that they can be replaced.

It works as follows. IC1 operates as a 100kHz oscillator with the frequency determined by a 22kΩ resistor and 100pF capacitor. Its complementary square wave outputs at pins 10 and 11 have a 50% duty cycle. The amplitude of both outputs is 10V peak-to-peak, swinging about zero volts. These signals are sent to four electronic switches in IC2, a 4066B. When the control input is at +5V, the resistance of the switch is about 50Ω, while at -5V it is virtually open circuit.

When the output at pin 10 of IC1 is high, switches IC2d and IC2a are closed and IC2c and IC2b are open. Conversely, if pin 11 is high, IC2d and IC2a are open and IC2b and IC2c are closed. This means either +5V or -5V is applied to the device under test (DUT, ie, a capacitor) between points "A" and "C" (GND), with around 2.4kΩ of total series resistance. Diodes D1-D4 prevent more than about ±0.5V from being applied to the DUT which could otherwise cause problems during in-circuit testing.

The voltage at the driven end of the capacitor is sensed at point "B" and this voltage charges one of two 1µF capacitors, depending on which of switches IC2a or IC2b is closed. Since these switch synchronously with IC2c and IC2d, these capacitors form a sample-and-hold buffer, to measure the voltage at the capacitor terminal. They both charge to a DC level that is proportional to the test capacitor's ESR but with opposite

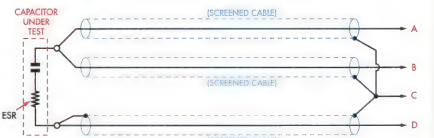


polarity. This signal is differentially amplified by op amps IC4a and IC4b and the resultant voltage is applied to analog input RA4 of IC5, a PIC16F88.

Pins RA2 and RA3 are used as the negative and positive reference voltages for the ADC respectively, with the positive reference coming from 2.5V shunt regulator REG1 (LM285Z). The 10-bit ADC gives a resolution of $2.5V \div 2^{10} = 2.4mV$. The circuit is designed so that a 10Ω resistor between the test terminals results in 2.44V at input RA4, giving an ADC result of 1000. So the software only has to divide the reading by 100 to get the Ohms value.

To determine if a capacitor or resistor is connected across the test terminals, we switch the 100kHz oscillator off for 10ms, by bringing output RA0 of IC5 high, and take another measurement. If the value measured is less than or equal to that when the oscillator is running, then the device is a resistor.

IC3 is a switched capacitor device which generates the -5V rail from the +5V rail. The +5V rail comes from REG1, a low-dropout regulator which is supplied from a 9V battery.



To avoid mains pick-up on the input leads it is necessary to use shielded cable, eg, microphone cable with crocodile clips soldered to one end. It's important to make the connections exactly as shown on the circuit diagram.

To calibrate the unit, remove IC1 from its socket and connect pin 11 directly to +5V and pin 10 to -5V. Short the capacitor test terminals, then measure the voltage drop across R1 (1.8kΩ) and record the value.

Now connect pin 11 to -5V and pin 10 to +5V. Adjust trimpot VR1 until the voltage across R1 is the same as before, then remove the links and replace IC1.

Alternatively, if you have an oscilloscope, set it on DC coupling and connect it across the capacitor test terminals along with a 10Ω resistor. Adjust VR1 so that the resultant square-wave swings symmetrically about 0V.

Next, short the capacitor test terminals and adjust VR2 so that the voltage on pin 7 of IC4b is 0V.

Finally, place a 10Ω 1% (or better) resistor across the capacitor test terminals. Adjust VR3 so that the display reads 10.00 OHM.

The software, PIC16ESR.BAS, can be downloaded from the Silicon Chip website.

Les Kerr,
Ashby, NSW. ($90)

Pt.2: By Jim Rowe

Arduino-based Multifunction 24-Bit Measuring System

Last month, we introduced our new Arduino-based Multifunction Meter (MFM) and gave the circuit details. This month, we describe how to install the software and firmware that's needed to control it from a desktop or laptop PC. We then explain how to get it going, how to calibrate the various ranges (if you have the facilities) and how to use the finished unit.

AS MENTIONED in Pt.1, a couple of pieces of software need to be installed on your PC in order to use the MFM. In addition, a "sketch" (Arduino-speak for firmware program) has to be uploaded into the flash memory of the Arduino to enable it to carry out its tasks.

This is detailed in the software block diagram of Fig.7. The large box at left represents a PC (desktop or laptop) running Windows XP/SP3 or later (you're not still using Windows XP, are you?). The MFM is shown over on the right, linked to the PC via a USB cable.

The MFM Control and Display Application (upper left) needs to be installed on the PC, together with a virtual COM port driver (lower right in the PC box) to allow it to communicate with the Arduino in the sampler. The Arduino IDE (integrated development environment) also needs to be installed in your PC, at least temporarily, in order to upload the MFM sketch to the Arduino module.

Here's the step-by-step procedure:

Step 1: download and install the Arduino IDE from the main Arduino website at **https://www.arduino.cc/en/Main/Software**. We've been using the **1.6.5-r2-windows.exe** version but there may be a later version available by the time you read this. There's also a zipped-up version.

The Arduino IDE comes with a USB virtual COM port driver to suit the Arduino Uno and this is installed in the "Drivers" folder of the IDE installation. As a result, if you are using an Arduino Uno in your sampler, you'll already have its matching USB port driver.

Alternatively, if you're using a Freetronics Eleven, go to **www.freetronics.com.au** and download their USB driver. At the time of writing, this was in a zip file called **FreetronicsUSB-Drivers_v2.2.zip**. Unzip this and make a note of where the files have been extracted.

Step 2: plug the cable from your MFM

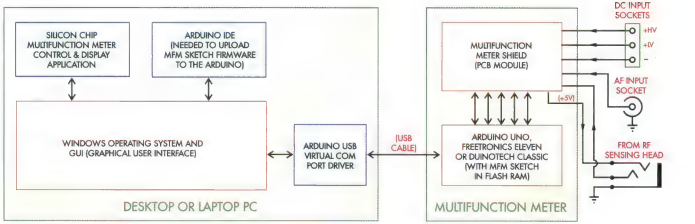


Fig.7: the software block diagram for the MFM system. The MFM connects to a Windows PC via a USB cable and is controlled by an application (app) running on the PC. The Arduino IDE software is required to upload the MFM "sketch" firmware to the Arduino module in the MFM.

into one of your PC's USB ports. The MFM's power LED should immediately turn on but Windows may not successfully install the driver right away.

Step 3: open up the Windows Device Manager. If you see a yellow error icon alongside an "Unknown device" listing, the driver has not installed automatically. If you then right-click the device and select Properties, it will be shown as either not working properly or not installed.

To fix this, select "Update Driver" in the Properties dialog and then "Browse my Computer for Driver Software". Then browse to either the Drivers folder of your Arduino IDE installation (to get Arduino's Uno driver) or, alternatively, to the folder where you unzipped the Freetronics driver software.

In either case, you should be able to find the **.inf** file that Windows needs to install the driver. Once it's installed, the Device Manager should then indicate that the device is working properly.

Step 4: go to the SILICON CHIP website (www.siliconchip.com.au) and download both the Windows software for the MFM Control & Display App (**SiliconChipMFM.zip**) and the matching Arduino firmware sketch (**ArduinoMFMSketch.ino**).

The firmware sketch should be saved in a sub-folder called "Arduino sketches" in your PC's Documents folder. That done, launch the Arduino IDE, direct it to that folder to find the sketch, open it, compile it and then upload it to the flash RAM in your MFM's Arduino. You will find that this is all quite straightforward.

Step 5: unzip the **SiliconChipMFM.zip** file to get the install package (**SiliconChipMFM.msi**), then run it to install the "Windows MFM Control and Display" application. You should then be ready to roll with your new 24-bit MultiFunction Meter.

Using the Windows app

Apart from the range selection (done via rotary switch S1), all functions on the MFM are controlled using the MFM Control and Display application. This is easy to use because when you fire it up, a GUI (Graphical User Interface) window appears (see Fig.8) which provides combo-boxes along the top so you can set the configuration of the MFM-PC serial link; ie, the (virtual) COM port to which it's connected and the baud rate (115,200).

There's also a third combo-box which allows you to select the external load resistance you will be using, if you intend using either the AF or RF level and power ranges. However, you don't have to worry about doing this if you simply intend measuring DC voltages.

Just below this top row of combo boxes is a box labelled "Sampling interval:". This allows you to select the sampling rate to be used when taking continuous or repetitive samples. You can choose from 13 different sampling intervals, ranging from 200ms (five samples per second) to 60s (one sample per minute).

Immediately to the right is a small check box with the label "Live reading". Clicking on this check box allows you to view MFM measurements in real time, at the same rate as that selected for continuous sampling. When "Live reading" is enabled, the measurements are displayed just to the right of the "Live reading" label itself, with each successive reading replacing the previous one.

By the way, "Live reading" may be enabled at the same time as continuous sampling, with the data for each measurement being displayed at top right as well as on the next available line in the main text box.

Further down the GUI window, you'll find two rectangular control buttons with red borders and red text labels reading "Take a Sample" and "Start Sampling" respectively. These allow you to either take a single measurement sample or to begin taking a series of samples at a rate corresponding to the selected sampling interval.

To the right of these two control buttons is a "Range Selected:" label, followed a text box which will initially be blank. However, when you begin taking measurement samples, this text box will show the MFM range that's been selected via range switch S1 on the MFM itself.

The lower portion of the GUI window is taken up by a text box which displays the measurement samples as they are made. Each sample is on a separate line and is preceded by the date and time at which it was taken.

In addition, when you first start sampling, the application displays a header line at the top showing not only the date and time but also the virtual COM port and serial data rate being used, plus the sampling interval

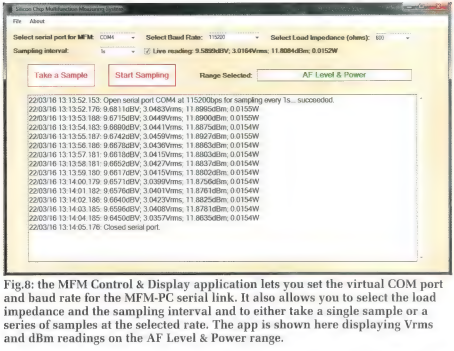


Fig.8: the MFM Control & Display application lets you set the virtual COM port and baud rate for the MFM-PC serial link. It also allows you to select the load impedance and the sampling interval and to either take a single sample or a series of samples at the selected rate. The app is shown here displaying Vrms and dBm readings on the AF Level & Power range.

selected. This is to make the MFM and its control application more suited for measurement data logging.

Making measurements

To take a measurement or a series of measurements, all you need to do is click on either the "Take a Sample" button or the "Start Sampling" button. The data then appears in the main textbox.

If you click the "Start Sampling" button, the unit will continue to take further measurements at the selected time interval. During this time, the button label also changes to read "Stop Sampling" and you can stop the sampling simply by clicking this button again.

So that's how simple it is to use our MFM Control and Display app for taking measurements. But what about saving the measurements? Easy – just click the "File" drop-down menu at top left on the window and you'll see a number of handy options for saving, reopening or printing out your current collection of measurement samples.

There's also an option called "New", for "clearing the slate" before taking another set of samples, plus the usual option of closing the application itself at the end of the job. These all work the same way as for other Windows applications, so you shouldn't have any problems.

MFM set-up & calibration

There are no trimpots or other hardware items to adjust in order to calibrate the MFM's DC voltage ranges. That's because we're taking advantage of the accuracy built into the LTC2400 24-bit ADC, its companion LT1019ACS8 voltage reference and the 0.1% tolerance resistors used in the input dividers. These will give you an accuracy of ±0.06% (±1.25mV) on the basic 2.5V range and ±0.5% on the three higher ranges (ie, ±125mV on the 25V range, ±1.25V on the 250V range and ±5V on the 1000V range), without any adjustments.

However, if you happen to have access to a high-accuracy DC voltmeter, it can be used to measure the exact reference voltage being provided by the LT1019ACS8 voltage reference in the MFM. You can then make a single change in the MFM Arduino's firmware sketch to improve the accuracy of its basic 2.500V DC range (and of all the other ranges by default).

If you want to do this, first remove the control knob and the lid of the MFM, then plug its USB cable into your PC and use the high-accuracy DC voltmeter to measure the voltage from REF1, the LT1019ACS8. The easiest way to do this is to place your meter's test probes across ZD1, the 3.9V zener diode located just behind REF1.

Be sure to write the measured reference voltage down carefully, using as many significant digits as your voltmeter provides. The reading should be somewhere between 2.49875V and 2.50125V, because the LT1019ACS8-2.5 has an initial accuracy of ±0.05%.

Next, launch the Arduino IDE in your PC, open up the MFM firmware sketch (ArduinoMFMSketch.ino) and move down the sketch listing until you get to the start of the main loop; ie, a line which reads:

```
void loop() {
```

The next line should read:

```
const float Vref = 2.50000f;   //Vref = the ADC reference voltage
```

Replace "2.50000" in the above line with your own measured reference voltage, then use the Arduino IDE software to recompile the sketch and upload it to the Arduino in your MFM. This will make its 2.5V DC range and all of the other ranges as accurate as possible without access to a full-scale calibration lab.

Audio Level & Power range

Unlike the DC voltage ranges, the Audio Level & Power range does require some hardware set-up and adjustment.

To do this, you need an audio-frequency sinewave signal of at least 10VAC (RMS) and some way of accurately measuring its level. One possibility is to use an audio signal generator with an output meter and attenuator, or you could use an uncalibrated audio oscillator with a separate audio level meter to monitor its output.

Another possibility is to use an AC plugpack (ie, one with a conventional iron-core transformer) with a 9-24VAC secondary to provide the sinewave signal, together with an RMS-reading AC voltmeter (to measure the output voltage). If you use this latter approach, you'll be doing the set-up at 50Hz but that's OK since 50Hz is well inside the audio range.

On the other hand, if you are using an audio signal generator, it's probably a good idea to set its frequency to around 1kHz.

Once you have a suitable signal source, just follow this step-by-step procedure to set up and adjust the MFM's Audio Level and Power range:

Step 1: connect the MFM to your PC and check that it's operating normally.

Step 2: launch the MFM Control & Display app and set it up to communicate with the MFM via the previously installed virtual COM port at 115,200 baud.

Step 3: move the MFM's range switch

to the fully anticlockwise "Audio Level & Power" position, then fit a 50Ω termination plug to the Audio Input BNC connector (this will ensure a nominal input of near enough to zero).

Step 4: select a short sampling interval (eg, 200ms) and enable the Live Reading display. You'll probably initially see dBV/Vrms figures that are somewhat higher than they should be with the input terminated in just 50Ω.

Step 5: use a small screwdriver to adjust trimpot VR1 (Intercept Adjust) via the small hole in the case immediately to the left of the Audio Input BNC connector to achieve minimum readings. Ideally, you'll be able to get readings well below -47.5dBV and 4.2mV RMS.

Step 6: remove the 50Ω plug from the Audio Input connector and connect your audio signal source in its place.

Step 7: make small adjustments to trimpot VR2 (Slope Adjust) via the small hole just to the right of the Audio Input BNC connector. Make the Vrms reading as close as possible to the voltage of the input signal.

If you can't achieve the known Vrms reading, you may need to repeat Steps 3-5 to make further small adjustments to trimpot VR1. For example, if your reading in Step 7 remains stubbornly higher than the known input level, try reducing the "zero input" reading by a small amount using VR1 before coming back to Step 7.

Conversely, if you are unable to increase the reading in Step 7 to reach the known input level, increase the "zero input" reading by a small amount. It should then be possible to achieve the known input level reading by adjusting VR2.

Once the known input level reading has been achieved, the Audio Level and Power range has been correctly set up and calibrated. Note that its accuracy will depend on the accuracy of your audio signal generator's level meter (or the accuracy of your AC voltmeter).

By the way, we ignored readings other than dBV and Vrms in the previous steps because the other values are calculated from these (taking into account the selected load impedance). That means that it's only necessary to have the load impedance setting correct if you are actually making dBm and power readings.

RF Level & Power range

This range is a bit simpler to calibrate since it's only necessary to adjust trimpot VR3 (Intercept Adjust) inside the companion RF Measuring Head.

This time, you will need an RF sinewave signal source (preferably unmodulated) and again some way of accurately measuring its level. You can either use an RF signal generator with an output meter and an attenuator or an uncalibrated RF oscillator or transmitter with a separate RF level meter to monitor its output.

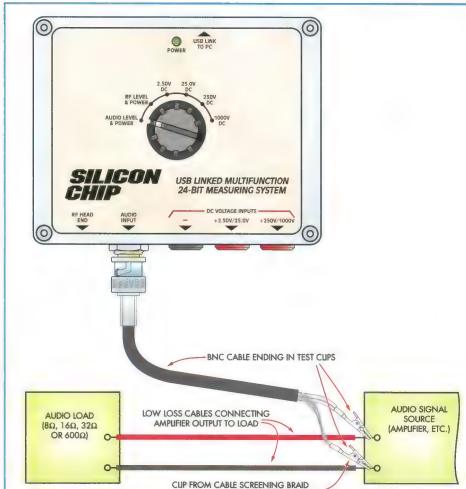


Fig.9: the MFM can be used to measure power levels from an audio amplifier using the configuration shown here. Be sure to use low-loss cable to connect the load and be careful not to short the amplifier output terminals.

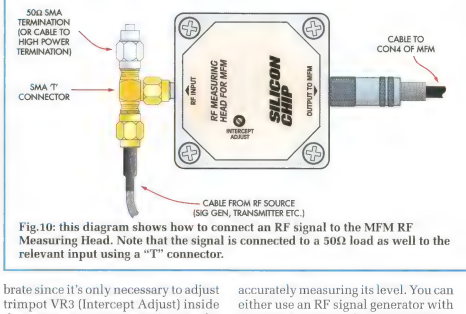


Fig.10: this diagram shows how to connect an RF signal to the MFM RF Measuring Head. Note that the signal is connected to a 50Ω load as well to the relevant input using a "T" connector.

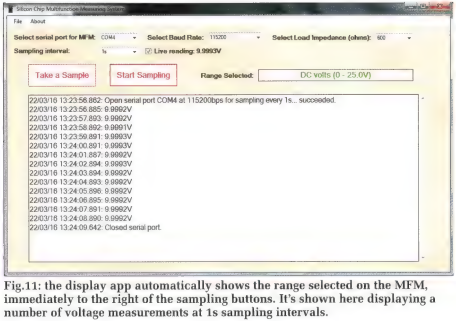


Fig.11: the display app automatically shows the range selected on the MFM, immediately to the right of the sampling buttons. It's shown here displaying a number of voltage measurements at 1s sampling intervals.

The frequency of the generator/oscillator should be set to around 1MHz, or at least no higher than 10MHz.

As before, here's the procedure you need to follow, step-by-step:

Step 1: plug the cable from the RF Measuring Head head into the 3.5mm "RF Head End" socket on the MFM.

Step 2: connect the MFM to your PC and check that it's operating correctly.

Step 3: launch the MFM Control & Display app, set it to communicate with the MFM via the listed COM port at 115,200 baud and with a load resistance of 50Ω.

Step 4: set the MFM's range switch S1 to the "RF Level & Power" position.

Step 5: connect your RF signal source to the RF Head's input using an SMA "T" connector, as shown in Fig.10. Also, fit a 50Ω dummy load with an appropriate power rating to the other end of the "T" connector.

Step 6: select a short sampling interval and enable Live Reading. As before, the figures you now need to check are for dBV and Vrms. They will probably be either too high or too low, compared to the level set on your RF signal source.

Step 7: use a small screwdriver to adjust trimpot VR3 (Intercept Adjust) via the small hole in the top of the RF Measuring Head until the dBV and Vrms values are as close as possible to the level set by your RF signal source.

Points to note

When setting the level of your RF signal source, make sure that its output cable is terminated in a 50Ω load. Most signal generators are calibrated this way but if you have one that isn't, you can be fooled into setting the MFM to read high by up to 6dB.

Another point to note is that when calibrating the "RF Level & Power" range, the RF signal source must be terminated at the input to the MFM head end. That's because if cables carrying RF signals are not terminated with the correct impedance at both ends, there will be reflections. As a result, standing waves can develop in the cable, leading to measurement errors.

This isn't necessary when calibrating the "AF Level & Power" range. In fact, given the amount of power that may be dissipated in the load resistance, you will normally connect the load directly to the Device Under Test (DUT) using heavy cables and run a smaller, shielded cable from the output terminals of the DUT to the MFM input.

Load resistors

The main thing to bear in mind when making dBm or power measurements is that the MFM does not have inbuilt load resistors. This applies to both the Audio Level & Power range and the RF Level & Power range. It would have been very complicated to do this and would not have suited all situations, so the MFM must be used with external load resistors for both these ranges.

If you already have AF or RF dummy loads with adequate power ratings for the power levels you want to measure, these can be used without modification. On the other hand, if you do need to acquire one or more dummy loads of a particular impedance and/or power level, they can be purchased or built for minimum outlay and no modifications to the MFM itself will be required. For example, 4Ω and 8Ω wirewound resistors with ratings of 50W and 100W are relatively cheap and are available from multiple suppliers.

What To Do If You're Missing A DLL

The Windows installer for the MFM software package includes a required set of DLLs (Dynamic Link Libraries), referred to as the "C Runtime Library" (CRT for short). They contain support routines required by software developed using Microsoft Visual Studio using C or C++. When you run the installer we supply, it checks to see if you already have the required version of the CRT DLLs on your system and if not, installs them.

But Microsoft has recently changed the way the CRT DLLs work. To avoid having to install a whole new set of DLLs for software built using each different version of Visual Studio, they now supply a set of "Universal CRT" DLLs with Windows. Developers then only need to bundle a smaller set of DLLs with their software, which in turn rely on the Universal CRT.

Windows 10 comes with these Universal CRT files out of the box but for Vista, Windows 7 and Windows 8, they are instead installed by Windows Update. For some reason, it seems that some PCs still lack these files, even with all the latest updates installed. If you try to launch our software on such a PC, you get the following error message:

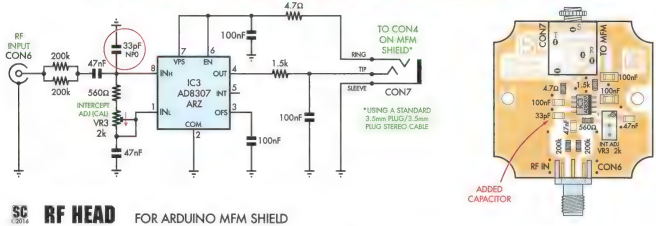
The program can't start because api-ms-win-crt-l1-1-0.dll is missing from your computer.

Try reinstalling the program to fix this problem.

If this happens, check that your PC has the latest updates installed. If so, you will need to download and install the Universal CRT files yourself. They can be found at the following location: www.microsoft.com/en-us/download/details.aspx?id=50410

If you're still using Windows XP (despite the fact that it's no longer supported!) this will almost certainly be necessary.

RF Measuring Head Modification



SC 5/2016 **RF HEAD** FOR ARDUINO MFM SHIELD

Fig.12: the RF Measuring Head needs to be modified by adding a 33pF NP0 capacitor between pin 8 (IN_H) of IC3 and ground, as shown here. This capacitor swamps the stray capacitance across the two 200kΩ input resistors and ensures that the RF Measuring Head remains accurate for frequencies above 10MHz.

Further testing of the MFM's RF Measuring Head has revealed the need for a 33pF NP0 capacitor to be added between the pin 8 (IN_H) of IC3 and ground.

Without this capacitor, the very small stray capacitance across the two paralleled 200kΩ input resistors causes the signal level into pin 8 of IC3 to increase as the input frequency rises above about 10MHz. In other words, the input voltage divider's division ratio gradually falls below its nominal low-frequency level of 158:1.

Adding the 33pF capacitor compensates for this stray capacitance by forming an additional, parallel capacitive voltage divider, maintaining the input division ratio at its correct level for higher frequencies. It ensures that the calibration of the MFM's RF Measuring Head is maintained up to the limit of the AD8307 log detector's measurement capability (around 500MHz).

Fig.12 shows the revised circuit and PCB layout diagrams for the RF Measuring Head. If you have the latest PCB version, just follow Fig.12 to build the unit as shown, with the extra capacitor.

Alternatively, if you have one of the earlier RF Head PCBs, it's quite easy to add the 33pF capacitor. First, scrape away a small patch of green resist coating from the top layer earth copper, to the left of pin 8 of IC3 and just below the 100nF bypass capacitor on pins 6 & 7. Tin this bared copper area (to provide for the capacitor's earth connection), then scrape away the green resist on the copper above the 47nF input capacitor (the one going to pin 8 of IC3) and tin this small area of bared copper as well.

We soldered a 1.5 x 2.5mm rectangle of flattened, thin (eg, 0.15mm) copper foil to the exposed copper to make a pad for the 33pF capacitor. However you could just solder the capacitor directly across the two areas of copper that are now exposed. Its final location should be very close to that shown in the revised PCB overlay diagram, Fig.12.

There is one further small point to remember when making RF level and/or power measurements via the RF Measuring Head: be sure to connect the RF Head to the MFM (ie, connect CON5 and CON7) before you plug the MFM's USB cable into your PC. The reason for this is that the +5V line can be briefly shorted to earth when these plugs are fitted into their sockets, so it's safer to make the connections before power is applied to the MFM.

Analysing & plotting data

The MFM Windows software saves sample data in a CSV format which can be loaded into Microsoft Excel, LibreOffice/OpenOffice Calc or just about any spreadsheet software. It's then a simple matter to plot or analyse this data.

For example, after opening a CSV file saved from the MFM App in Calc, simply click OK on the Import dialog and the data should appear, with column "A" containing the time stamp for each sample, column "B" the sample number (starting with 0 for the first sample in each sequence), column "C" the number of milliseconds that each sample was taken relative to the first and the remaining columns ("D" and so on) containing the sample values.

If you want to plot a set of samples, first click on column "C" just before the first sample you're interested in, which should read "Milliseconds". Then, shift-click on the data you want to plot in the last row, which may be in one of the columns titled "V", "dbV", "Vrms" and so on.

Then, under the "Insert" menu at the top of the window, go to the "Object" sub-menu and click on "Chart". There are various types of chart to choose from, we suggest starting with "X-Y (Scatter)". You can then select either Points, Points and Lines or Lines and click Next twice. Select any data series you don't want to plot in the box at left and click "Remove" to get rid of them. Then click Finish and the chart should appear. You can make further changes; see the documentation and internet forums for more details.

Note that both LibreOffice Calc and OpenOffice Calc are free downloads. They can also analyse this data, doing calculations such as variance analysis, correlations, moving averages and so on (as can Excel). Check the documentation of these software packages for more information. SC

PRODUCT SHOWCASE

Tecsun Radio HF Antenna

The Tecsun Shortwave Outdoor Antenna significantly enhances reception of signals in the medium wave (AM) and shortwave bands covering 0.5-30MHz.

The Tecsun Shortwave Outdoor Antenna is based on the longwire antenna design but provides significantly improved reception over a longwire, because the Tecsun Shortwave Outdoor Antenna utilises a matching transformer that acts as a balun with a ratio of 10:1. This provides an optimal match between the 500Ω antenna and the 50Ω input of the external antenna input of a radio greatly increasing the amount of signal provided to the tuner.

The antenna's coax feeder acts as a counterpoise for the antenna, therefore no connection to ground is necessary. However, the stainless steel eyelet which is connected to the balun is internally grounded, if reception is noisy this can be grounded to an external earth.

The coaxial cable is terminated in a mono 3.5mm plug that suits many portable shortwave receivers, including the Tecsun PL310ET, Tecsun PL600, Tecsun PL660, Tecsun PL680, and Tecsun PL880.

The antenna is omnidirectional and can be used indoors or outdoors and is completely waterproof.

Contact:
Tecsun Radios Australia
Unit 24, 9 Powells Road, Brookvale NSW 2100
Tel: (02) 9939 4377
Web: www.tecsunradios.com.au

Ethernet DAQ Unit and Datalogger

The Teracom TCW220 from Ocean Controls is an Ethernet data logger for general data acquisition applications.

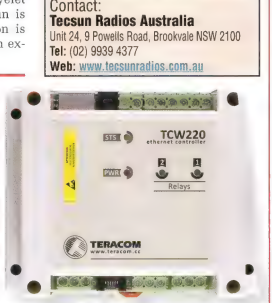
It has two analog inputs, with 10-bit resolution and two digital inputs. It utilises a 1-Wire interface for up to eight 1-Wire sensors (carbon dioxide, 0/20mA, AC/DC current, temperature, humidity etc.)

The Ethernet data logger also has two relays with normally open and normally close contacts.

All monitored parameters can be logged on previous set time interval and/or on alarm condition. The memory is large enough for at least 36 days with records on every 60 seconds. The XML/JSON log file can be periodically uploaded to a dedicated server by HTTP Post.

The server can return commands to control the relays. This is a way to build a SCADA system.

The relays can be activated either remotely (WEB, SNMP, HTTP, MODBUS etc.) or locally based in the monitored parameters.



For every parameter e-mails and SNMP traps for up to 5 recipients can be sent. Alarm alert also can be sent by HTTP Post with an XML/JSON status file.

Contact:
Ocean Controls
PO Box 2191, Seaford BC, Vic 3198
Tel: (03) 9782 5882
Web: www.oceancontrols.com.au

How to order PCB production service online

If you're new to the PCB industry, it's necessary to know how to place PCB orders online. In order to make your project on time and on budget, you should work with professional PCB manufacturers which offer flexible ordering options.

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Step three: Click "Add to Cart" in the right column. You can supplement your shipping address, payment method & delivery method, upload PCB files in the new page.
Step four: Click "Submit Order" in the checkout page. Please release the payment as soon as possible. Generally speaking, as soon as your payment is released, sales agents will follow your order.
Step five: Engineers from PCBCart will review your design file and send a report to notify you of any problem or question they have on the design. Production will be scheduled once all is clear.
Step six: As a rule, PCBCart will NOT schedule the delivery until it has checked the performance and quality of the finished PCBs by several quality tests.

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Arduino M0 Pro Development Board

The Arduino M0 Pro Development Board is based on a 32-bit ARM Cortex M0+ core and features the ATSAMD21G18 MCU. Want to be more innovative with your designs?

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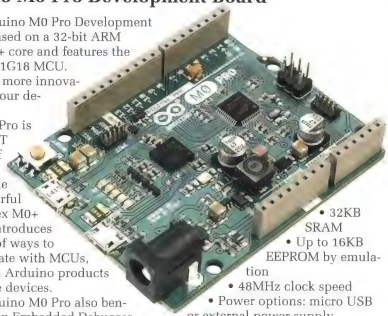
Features & Benefits of the M0 Pro

- ATSAMD21G18 MCU
- 32-bit ARM Cortex® M0+ core
- On-board Embedded Debugger
- 3.3V operating voltage
- 256KB flash memory



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Vintage Radio

By Associate Professor Graham Parslow

The 1948 AWA model 517M mantel radio

Designed for the budget end of the market, the AWA model 517M is a conventional 4-valve radio that was produced just a few years after the end of WW2. Restoring this one proved to be quite a challenge.

In 2008, I acquired a 1946 AWA model 500M (the prelude to the 517M) which I regard as a classic of simple design. It's the same size as the later model 517M and its components and layout are almost identical.

The older 500M is a 4-valve mantel set with two conventional front control knobs for tuning and volume. A problem with this design is that dial string drive between the tuning capacitor and the dial indicator is unreliable. In use, the dial indicator has a tendency to slip out of alignment with the tuned station.

This was corrected for the model 517M which has concentric control knobs at the centre of the dial. In this model, the outer dial knob is solidly geared to the tuning capacitor, so that sweeping the dial through 300° reliably rotates the vanes of the tuning capacitor through the required 180°. The centre knob controls the volume.

In addition, the 517M's case differs from the 500M's by having a domed top and a more elaborate speaker grille pattern.

The radio featured here was acquired at an auction. It was sold as damaged and had a long crack in the top of the cabinet. In addition, a rather large chunk of the cabinet was missing. There were also smears of paint and other foreign material on the cabinet which further detracted from its appearance.

As can be imagined, the bidding wasn't highly competitive and I was able to obtain the radio at a moderate cost. In spite of its damaged and dilapidated appearance, I was confident that it could be restored to full working order.

Circuit details

Fig.1 shows the circuit details of the AWA Radiola 517M. It's a conventional superhet with a 6A8 mixer-oscillator, a 6G8 IF amplifier/detector/AGC stage, a 6V6 output pentode and a 5Y3 which provides full wave rectification to produce the HT rail. The design provides grid bias by connecting the mains transformer's HT secondary centre-tap to earth via a resistor network, a technique which eliminates the need for bypass capacitors on the valve cathodes.

One feature omitted from the circuit diagram is the simple "top-cut" tone control that's located at the rear of the chassis. This consists of a 0.02μF capacitor and 500kΩ potentiometer connected in series between the plate of the 6V6 and earth.

Restoring the case

The crack in the top of the case had previously been glued but the bond had completely failed. It was re-glued, this time using PVA glue. PVA is not an intuitive choice for this type of repair but experience has shown that the bond is more enduring than for other glues. A possible explanation for this is that aqueous PVA penetrates the Bakelite filler (often sawdust) more completely and as a bonus, it leaves only a slight amount of external residue.

PVA adhesive works by tangling polymer molecules together to link the materials being bonded. No chemical change is involved; it simply dries out, so the gluing is reversible.

The glued crack was subsequently

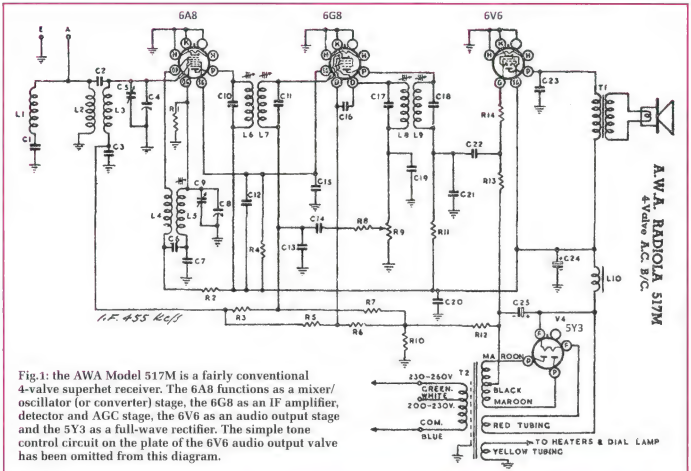


Fig.1: the AWA Model 517M is a fairly conventional 4-valve superhet receiver. The 6A8 functions as a mixer/oscillator (or converter) stage, the 6G8 as an IF amplifier, detector and AGC stage, the 6V6 as an audio output stage and the 5Y3 as a full-wave rectifier. The simple tone control circuit on the plate of the 6V6 audio output valve has been omitted from this diagram.

covered with grey car filler putty and sanded back to a smooth surface. I initially made the mistake of using wet and dry abrasive with water, as I had wrongly assumed that the grey putty would provide an impervious barrier. Unfortunately, water seeped into the crack and dissolved the PVA glue, causing the crack to open up again. As a result, I had to redo this repair.

It was not immediately obvious how the large section missing from the side and base of the cabinet was going to be replaced. The base has two moulded strips running from front to back that act as feet under the case. One of these feet only had the front half remaining, so something had to be done to provide a serviceable base.

In the end, the solution was to cut out a base of 3-ply that would look like an extra moulded layer under the radio. Contact glue was used to fix this new base in place, after which 2-part car-filler (bog) was used to fill the gaps between the ply and the original feet.

Once the new base was in place, filling the hole left in the side of the case was straightforward. A section cut from a plastic cylinder was taped to the inside of the gap and bog applied from the outside using a spatula. This bog was roughly crafted to the final shape but well proud of the wanted profile.

The AWA 517M's cabinet was in poor condition when received, with a large crack in the top and a large piece missing from the bottom and one side.

After allowing it to set for 20 minutes, a rasp was then used to further shape the profile, so that it was very close to what was wanted. It was then just a matter of using some spray putty

At left is another view of the damaged cabinet while the view at right shows the unit with repairs well under way. The bottom of the case was repaired by gluing a new base made from 3-ply under the existing base, while the hole in the side was filled using a section cut from a plastic cylinder. Car-filler "bog" was then used to fill the gaps.

and sanding to give the final finish.

Unfortunately, restoration to the original mahogany Bakelite finish wasn't a practical option. However, the model 517M came in a number of other attractive colours, so spray-painting the case was the obvious answer.

I wanted a light colour and previous experience has shown the value of starting with a light undercoat. The case was therefore sprayed with white undercoat inside and out. I was keen to try vivid yellow and I applied an experimental coat to the inside of the case. My wife said "yuck" to yellow so I reached for a spray can of Heritage Cream and this turned out to be a good choice.

The rusty-red speaker grille cloth

This tattered manufacturing label was attached to the inside of the cabinet. It clearly shows the connection between the 6A8's top grid and the tuning gang.

that came with the radio had faded strips and had also frayed at the edges. Fortunately, some speaker grille fabric I'd purchased from Mack's Electronics in Rundle St, Adelaide during the 1960s had an appropriate yellow and brown pattern combination and, in fact, was similar to some of the patterns used by AWA.

A piece of this cloth was cut to size and glued to the inside of the case, giving a flush finish. This gave a better appearance than the original mounting method, which involved attaching the cloth to a cardboard baffle that was riveted to the frame of the 5-inch speaker.

Chassis restoration

The chassis on the old model 517M was rusted and dusty, so it wasn't only the case that had suffered with age.

My first step was to remove the valves and here I got a surprise. Instead of a 6V6 output pentode, this radio had a 6AU4 installed. So was this an equivalent? The answer is a resounding "no". It's not even close because the 6AU4 is a single plate, half-wave rectifier that was used in high-current applications in early TV sets. It had simply been plugged into the 6V6's socket to give the appearance of a full complement of valves!

Another strange "modification" involved a connection between the 6A8's top grid and the antenna post. Fortunately, establishing the correct connection to the tuning capacitor was easy. It was just a matter of referring to the tattered layout diagram that had been glued to the inside of the case.

The top of the chassis was thoroughly cleaned and any corrosion rubbed back with abrasive paper. The rusted sections were then covered with metallic silver paint. This sacrificed the original stencilled chassis lettering and the ARTS&P label. As a result, reproductions were computer-generated and printed onto acetate transparencies before being attached to the rear of the chassis.

The earlier model 500M had two narrow straps of metal running under the chassis from front to back to reinforce the structure. These also acted as anchor points for the screws which fastened the chassis to the case.

By contrast, in the 517M, a pair of wrap-around end sections are attached to the chassis to serve the same functions. This more substantial metalwork also provides extra shielding, the only disadvantage being that a significant number of components cannot be accessed without removing these brackets (not too difficult, fortunately).

Component replacement

All but one of the components looked original, the exception being the second HT electrolytic filter capacitor. This had obviously been replaced at some stage.

The low-value capacitors were each sheathed in a one-piece moulded pitch case. This is arguably superior to the earlier style end-filled pitch case with a cardboard cylinder as a cover. Even so, after many years, the pitch contracts and splits and a number of cracks were visible in some of the capacitor cases (and in coil cases).

Because it has a high voltage applied

across it, capacitor C22 was replaced as a matter of routine. This capacitor couples the signal output from the 6G8 to the 6V6 audio output stage.

The model 517M has a rear-mounted DPDT switch for the mains and this was used to switch both strands of the original twin-core mains flex. This is clearly superior to single-pole switching which could result in 240VAC mains Active being connected directly to the transformer (the conventions for connecting Active and Neutral to sockets were not introduced until the 1950s). This DPDT switch was retained when the original twin-core mains flex was replaced with a 3-core mains lead. This new lead was firmly clamped inside the chassis and allowed the chassis to be securely earthed, in the interests of safety.

The original first HT electrolytic was mounted above the chassis adjacent to the power transformer. This was left in position to maintain the set's appearance but was disconnected and a new 33µF 450V electrolytic wired into place under the chassis.

One thing that did puzzle me was what looked like the end stub of a capacitor connected to earth. A bit of circuit tracing showed that C3 (0.05µF) was missing and may even have exploded. The other end of C3 connects to the aerial coil and a short pig-tail stub was evident on one of the aerial coil lugs. A new 0.047µF 630V capacitor was fitted in its place.

Powering up

Now for a smoke test. As a precaution, the set was initially powered up without the valves and this produced a steady power consumption of 8.2W which was about what was expected. This figure increased to just 13W when the valves were subsequently installed and there was no HT.

The problem was easy to diagnose; the 5Y3 rectifier's heater had gone open circuit. Replacing this valve restored the HT and increased the set's power consumption to a more reasonable 48W.

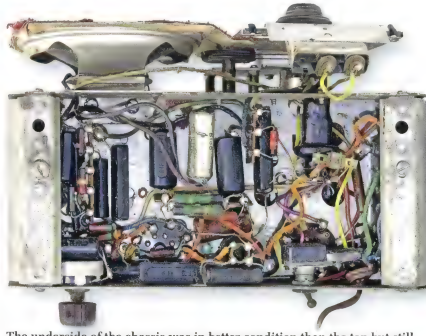
The set now worked but there was a disconcerting high background noise in the audio due to electromagnetic interference (EMI). This was quickly traced to a bank of mains-powered LED lights in an adjacent room and the solution was to simply switch them off.

However, although the set was working, there were clearly problems. It was exhibiting erratic changes in volume, a persistent background noise was still evident and the loudspeaker rattled at high volume. I began by checking the voltages on the 6V6. Its plate was at 248V, the screen was at 261V and the grid was excessively negative at -15.8V.

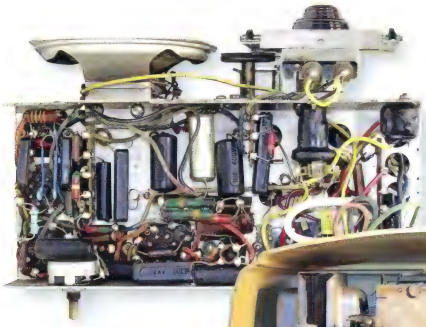
As a result, the grid voltage was reduced to -11.7V by adding a 560kΩ resistor in parallel with R13, the aim being to avoid operating the 6V6 non-linearly and thereby reduce the distortion. This raised the set's power consumption to 51W but it hardly altered the poor sound quality.

The rattle could be controlled by putting finger pressure on the back of the speaker cone. Removing the riveted front baffle immediately revealed the cause of the problem. The entire circumference of the speaker cone had come adrift and was rattling against the frame when the set was operated. Reattaching the cone to its frame with craft glue stopped the rattle.

This view shows the top of the chassis before restoration. A 6AU4 had been fitted in place of the 6V6 output valve but it is completely unsuitable for this role since it is a half-wave rectifier.



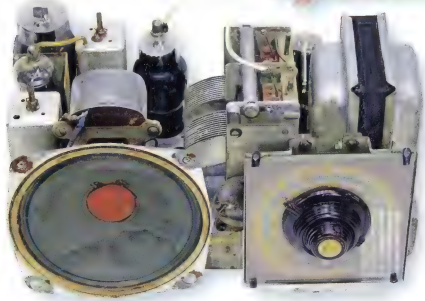
The underside of the chassis was in better condition than the top but still required work. Note the crude knot used to restrain the original twin-flex mains cord (now illegal).



Left: an under-chassis view of the unit after restoration. Despite the set's age, only a few parts required replacement

Below: the fully-restored chassis after it had been fitted into the repaired (and repainted) cabinet. The ARTS&P label was reproduced on a computer and printed onto an acetate transparency before being affixed to the rear of the chassis.

Below: a top-side view of the fully-restored chassis. An additional metal shield was later added adjacent to the 6G8 IF amplifier/detector valve to reduce the set's sensitivity to electromagnetic interference.



The erratic sound level problem appeared to come and go when I prodded R11 (16kΩ), C19 (200pF) and C21 (0.001μF). All were replaced but the erratic sound level variations continued. Further prodding then cast suspicion on the wiring between the antenna post, the antenna coil and the oscillator coil. This wiring was replaced but the set still continued to misbehave.

It was time to be to analyse the fault a bit more carefully. The power consumption remained constant during the set's erratic performance so I figured that it was probably a component in the audio signal path. And that proved to be the case; the faulty component was capacitor C14 which feeds audio to the volume control's wiper via series resistor R8. It had a crack around one end of its case and prodding almost anywhere in the radio was enough to cause the erratic volume changes.

In fact, the crack had penetrated so deeply that the faulty end of the capacitor broke away as it was being removed.

Fixing the EMI problem

The set's sensitivity to EMI was annoying and the cause was poor shielding of the 6G8 IF amplifier valve. In fact, some valve radios completely fail to function without shielded IF stages.

Hence, a supplementary shield was fitted around the 6G8 and soldered to the side of the chassis. This proved to be quite successful, as the sound quality was much improved and the set now turned in quite a good performance.

So that was another vintage radio rescued from the scrap-heap. Restoring it was quite a challenge but it was well worthwhile. SC

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OK, so how do you go about it?

It's simple: you can **order your subscription online**, 24 hours a day (siliconchip.com.au/shop and follow the prompts); you can send us an **email** with your subscription request and credit card details (silicon@siliconchip.com.au), or you can **phone** us, Monday-Friday, 9am-4.30pm, on (02) 9939 3295 (international 612 9939 3295).

Don't put it off any longer: $TART $AVING TODAY with a SILICON CHIP ubcription!

www.siliconchip.com.au

SILICON CHIP .com.au/shop ONLINESHOP

Looking for a specialised component to build that latest and greatest *Silicon Chip* project? Maybe it's the PCB you're after?
Or a pre-programmed micro? Or some other hard-to-get "bit"? The chances are they are available direct from the *Silicon Chip* ONLINESHOP.

As a service to readers, *Silicon Chip* has established the ONLINESHOP. No, we're not going into opposition with your normal suppliers – this is a direct response to requests from readers who have found difficulty in obtaining specialised parts such as PCBs & micros.

- PCBs are normally IN STOCK and ready for despatch when that month's magazine goes on sale (you don't have to wait for them to be made!).
- Even if stock runs out (eg, for high demand), in most cases there will be no longer than a two-week wait.
- One low p&p charge: $10 per order, regardless of how many boards or micros you order! (Australia only; overseas clients – email us for a postage quote).
- Our PCBs are beautifully made, very high quality fibreglass boards with pre-tinned tracks, silk screen overlays and where applicable, solder masks.
- Best of all, those boards with fancy cut-outs or edges are already cut out to the *SILICON CHIP* specifications – no messy blade work required!

HERE'S HOW TO ORDER:

VISA MasterCard PayPal

- ✔ **Via the INTERNET** (24 hours, 7 days): Log on to our secure website – siliconchip.com.au, click on "SHOP" and follow the links
- ✔ **Via EMAIL** (24 hours, 7 days): email silicon@siliconchip.com.au – Clearly tell us what you want and include your contact and credit card details
- ✔ **Via MAIL** (24 hours, 7 days): PO Box 139, Collaroy NSW 2097. Clearly tell us what you want and include your contact and credit card details
- ✔ **Via PHONE** (9am-5pm EADST, Mon-Fri): Call (02) 9939 3295 (INT 612 9939 3295) – have your order ready, including contact and credit card details!

YES! You can also order or renew your SILICON CHIP subscription via any of these methods as well!

PRE-PROGRAMMED MICROS

Price for any of these micros is just $15.00 each + $10 p&p per order#

As a service to readers, *Silicon Chip OnlineShop* stocks microcontrollers and microprocessors *used in new projects* (from 2012 on) and some selected older projects – pre-programmed and ready to fly!

Some micros from copyrighted and/or contributed projects may not be available.

PIC12F675-I/P	UHF Remote Switch (Jan09), Ultrasonic Cleaner (Aug10), Ultrasonic Anti-fouling (Sep10), Cricket/Frog (Jun12) Do Not Disturb (May13) IR-to-UHF Converter (Jul13), UHF-to-IR Converter (Jul13) PC Birdies *(2 chips – $15 per pair)* (Aug13), Driveway Monitor Receiver (July15)
PIC16F1507-I/P	Wideband Oxygen Sensor (Jun-Jul12)
PIC16F88-E/P	Hi Energy Ignition (Nov/Dec12), Speedo Corrector (Sept13), Auto Headlight Controller (Oct13); 10A 230V Motor Speed Controller (Feb14)
PIC16F88-I/P	Projector Speed (Apr11), Vox (Jun11), Ultrasonic Water Tank Level (Sep11), Gazzonat (Oct11) Ultra LD Preamp (Nov11), 10-Channel Remote Control Receiver (Jun13), Revised 10-Channel Remote Control Receiver (Jul13), Nicad/NiMH Burp Charger (Mar14), Remote Mains Timer (Nov14), Driveway Monitor Transmitter (July15); Fingerprint Scanner (Nov15), MPPT Lighting Charge Controller (Feb16) *50/60Hz Turntable Driver (May16)*
PIC16LF88-I/P	Garbage Reminder (Jan13), Beltbird (Dec13)
PIC16LF88-I/SO	LED Ladybird (Apr13)
PIC16LF1709-I/SO	Battery Cell Balancer (Mar16)
PIC16F877A-I/P	6-Digit GPS Clock (May-Jun09), Lab Digital Pot (Jul10) Semtest (Feb-May12)
PIC18F2550-I/SP	Batt Capacity Meter (Jun09), Intelligent Fan Controller (Jul10)
PIC18F45K80	USB Power Monitor (Dec12)
PIC18F4550-I/P	GPS Car Computer (Jan10), GPS Boat Computer (Oct10)
PIC18F14K50	USB MIDIMate (Oct11)
PIC18F27J53-I/SP	USB Data Logger (Dec10-Feb11)
PIC18LF14K22	Digital Spirit Level (Aug11), G-Force Meter (Nov11)
PIC32MX795F512H-80I/PT	Maximite (Mar11), miniMaximite (Nov11), Colour Maximite (Sept/Oct12), Touchscreen Audio Recorder (Jun/Jul14)
PIC32MX170F256B-50I/SP	Micromite MK2 (Jan15) – *also includes* ***FREE*** *47µF tantalum capacitor* Micromite LCD Backpack [either version] (Feb 16), Parking Assistant (Mar 16)
PIC32MX170F256B-I/SP	Low Frequency Distortion Analyser (Apr15) Bad Vibes (June 15)
PIC32MX170F256D-50I/PT	44-pin Micromite Mk2 (Now with MK2 Firmware at no extra cost)
PIC32MX250F128B-I/SP	GPS Tracker (Nov13) Micromite ASCII Video Terminal (Jul14)
PIC32MX470F512H-I/PT	Stereo Audio Delay/DSP (Nov13), Stereo Echo/Reverb (Feb 14), Digital Effects Unit (Oct14)
dsPIC33FJ128GP802-I/SP	Digital Audio Signal Generator (Mar-May10), Digital Lighting Controller (Oct-Dec10), SportSync (May11), Digital Audio Delay (Dec11) Level (Sep11) Quizzicator (Oct11), Ultra-LD Preamp (Nov11), LED Musicolor (Nov12)
dsPIC33FJ64MC802-E/P	Induction Motor Speed Controller (revised) (Aug13)
dsPIC33FJ128GP306-I/PT	CLASSIC DAC (Feb-May 13)
ATTiny861	VVA Thermometer/Thermostat (Mar10), Rudder Position Indicator (Jul11)
ATTiny2313	Remote-Controlled Timer (Aug10)

When ordering, be sure to nominate BOTH the micro required AND the project for which it must be programmed.

SPECIALISED COMPONENTS, HARD-TO-GET BITS, ETC

P&P – $10 Per order#

NEW THIS MONTH:
RASPBERRY PI TEMPERATURE SENSOR EXPANSION

Two BSO150N03 dual N-channel Mosfets plus 4.7kΩ SMD resistor:	*(May16)*	**$5.00**
MICROWAVE LEAKAGE DETECTOR - all SMD parts:	*(Apr16)*	**$10.00**
BOAT COMPUTER - **(REQUIRES MICROMITE LCD BACKPACK – $65.00 (see below))**	*(Apr16)*	
BOAT COMPUTER - VK2828U7G5LF TTL GPS/GLONASS/GALILEO module with antenna & cable:		**$25.00**
BOAT COMPUTER - VK16E TTL GPS module with antenna & cable:	*(Apr16)*	**$20.00**
ULTRASONIC PARKING ASSISTANT (REQUIRES MICROMITE LCD BACKPACK – $65.00 (see below) Ultrasonic Range Sensor PLUS clear lid with cutout to suit UBS Jiffy Box	*(Mar 16)*	**$7.50**
BATTERY CELL BALANCER		
ALL SMD PARTS, including **programmed micro**	*(Mar 16)*	**$50.00**
MICROMITE LCD BACKPACK *** COMPLETE KIT ******* includes PCB, micro and 2.8-inch touchscreen	*(Feb 16)*	**$65.00**
VALVE STEREO PREAMPLIFIER - 100µH SMD inductor, 3x low-profile 400V capacitors & 0.33Ω resistor	*(Jan 16)*	**$30.00**
MINI USB SWITCHMODE REGULATOR Mk II all SMD components	*(Sept15)*	**$15.00**
ARDUINO-BASED ECG SHIELD - all SMD components	*(Oct-15)*	**$25.00**
ULTRA LD Mk 4 - plastic sewing machine bobbin for L2 – pack 2	*(Oct-15)*	**$2.00**
VOLTAGE/CURRENT/RESISTANCE REFERENCE - all SMD components# # includes precision resistor. Specify either 1.8V or 2.5V	*(Aug 15)*	**$12.50**
MINI USB SWITCHMODE REGULATOR all SMD components	*(July 15)*	**$10.00**
BAD VIBES INFRASOUND SNOOPER - TDA1543 16-bit Stereo DAC IC	*(Jun-15)*	**$2.50**
BALANCED INPUT ATTENUATOR - all SMD components inc:12 NE5532D ICs, 8 SMD diodes, SMD caps, polypropylene caps plus all 0.1% resistors (SMD & through-hole)	*(May 15)*	**$65.00**
APPLIANCE INSULATION TESTER - 600V logic-level Mosfet. 5 x HV resistors:	*(Apr15)*	**$10.00**
ISOLATED HIGH VOLTAGE PROBE - Hard-to-get parts pack: all ICs, 1N5711 diodes, LED, high-voltage capacitors & resistors:	*(Jan15)*	**$40.00**
CDI – Hard-to-get parts pack: Transformer components (excluding wire), all ICs, Mosfets, UF4007 diodes, 1µF X2 capacitor:	*(Dec 14)*	**$40.00**
CURRAWONG AMPLIFIER Hard-to-get parts pack: MJ10047-ADJ, KSS5603D, 3 x STO2560, 5 x blue 3mm LEDs, 5 x 39µF 400V low profile capacitors	*(Dec 14)*	**$50.00**
ONE-CHIP AMPLIFIER - All SMD parts	*(Nov 14)*	**$15.00**
DIGITAL EFFECTS UNIT WM8371 DAC IC & SMD Capacitors *(Same components also suit Stereo Echo & Reverb, Feb14 & Dual Channel Audio Delay Nov 14)*	*(Oct14)*	**$25.00**
AD8038ARZ Video Amplifier ICs (SMD) For Active Differential Probe (Pack of 3)	*(Sept 14)*	**$12.50**
44-PIN MICROMITE Complete kit inc PCB, micro etc	*(Aug14)*	**$35.00**
MAINS FAN SPEED CONTROLLER - AOT11N60L 600V Mosfet	*(May14)*	**$5.00**
RGB LED STRIP DRIVER - all SMD parts and BSO150N03 Mosfets, does not include micro (see above) nor parts listed as "optional"	*(May14)*	**$20.00**
HYBRID BENCH SUPPLY - all SMD parts, 3 x BCM856DS & L2/L3	*(May 14)*	**$45.00**
USB/RS232C ADAPTOR MCP2200 USB/Serial converter IC	*(Apr14)*	**$7.50**
NICAD/NIMH BURP CHARGER 1 SPD15P10 P-channel logic Mosfet & 1 IPP230N06L3 N-channel logic Mosfet	*(Mar14)*	**$7.50**
10A 230V AC MOTOR SPEED CONTROLLER 40A IGBT, 30A Fast Recovery Diode, IR2125 Driver and NTC Thermistor	*(Feb14)*	**$45.00**

THESE ARE ONLY THE MOST RECENT MICROS AND SPECIALISED COMPONENTS. FOR THE FULL LIST, SEE www.siliconchip.com.au/shop

All items subject to availability. Prices valid for month of magazine issue only. All prices in Australian dollars and included GST where applicable. **#P&P prices are within Australia. O'seas? Please email for a quote**

05/16

PRINTED CIRCUIT BOARDS

NOTE: The listings below are for the PCB only – *not a full kit.* If you want a kit, contact the kit suppliers advertising in this issue. For more unusual projects where kits are not available, some have specialised components available – see the list opposite.

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
ZENER DIODE TESTER	NOV 2011	04111111	$20.00
MINIMAXIMITE	NOV 2011	07111111	$10.00
ADJUSTABLE REGULATED POWER SUPPLY	DEC 2011	18112111	$5.00
DIGITAL AUDIO DELAY	DEC 2011	01121111	$25.00
DIGITAL AUDIO DELAY Front & Rear Panels	DEC 2011	01121112/3	$20 per set
AM RADIO	JAN 2012	06101121	$10.00
STEREO AUDIO COMPRESSOR	JAN 2012	01201121	$30.00
STEREO AUDIO COMPRESSOR FRONT & REAR PANELS	JAN 2012	01201121P1/2	$20.00
3-INPUT AUDIO SELECTOR (SET OF 2 BOARDS)	JAN 2012	01101121/2	$30 per set
CRYSTAL DAC	FEB 2012	01102121	$20.00
SWITCHING REGULATOR	FEB 2012	18102121	$5.00
SEMTEST LOWER BOARD	MAR 2012	04103121	$40.00
SEMTEST UPPER BOARD	MAR 2012	04103122	$40.00
SEMTEST FRONT PANEL	MAR 2012	04103123	$75.00
INTERPLANETARY VOICE	MAR 2012	08102121	$10.00
12/24V 3-STAGE MPPT SOLAR CHARGER REV.A	MAR 2012	14102112	$20.00
SOFT START SUPPRESSOR	APR 2012	10104121	$10.00
RESISTANCE DECADE BOX	APR 2012	04104121	$20.00
RESISTANCE DECADE BOX PANEL/LID	APR 2012	04104122	$20.00
1.5kW INDUCTION MOTOR SPEED CONT. (Rev V2 PCB)	APR (DEC) 2012	10105122	$35.00
HIGH TEMPERATURE THERMOMETER MAIN PCB	MAY 2012	21105121	$30.00
HIGH TEMPERATURE THERMOMETER Front & Rear Panels	MAY 2012	21105122/3	$20 per set
MIX-IT! 4 CHANNEL MIXER	JUNE 2012	01106121	$20.00
PIC/AVR PROGRAMMING ADAPTOR BOARD	JUNE 2012	24105121	$30.00
CRAZY CRICKET/FREAKY FROG	JUNE 2012	08106121	$10.00
CAPACITANCE DECADE BOX	JULY 2012	04106121	$20.00
CAPACITANCE DECADE BOX PANEL/LID	JULY 2012	04106122	$20.00
WIDEBAND OXYGEN CONTROLLER MK2	JULY 2012	05106121	$20.00
WIDEBAND OXYGEN CONTROLLER MK2 DISPLAY BOARD	JULY 2012	05106122	$10.00
SOFT STARTER FOR POWER TOOLS	JULY 2012	10107121	$10.00
DRIVEWAY SENTRY MK2	AUG 2012	03107121	$20.00
MAINS TIMER	AUG 2012	10108121	$10.00
CURRENT ADAPTOR FOR SCOPES AND DMMS	AUG 2012	04108121	$20.00
USB VIRTUAL INSTRUMENT INTERFACE	SEPT 2012	24109121	$30.00
USB VIRTUAL INSTRUMENT INT. FRONT PANEL	SEPT 2012	24109122	$30.00
BARKING DOG BLASTER	SEPT 2012	25108121	$20.00
COLOUR MAXIMITE	SEPT 2012	07109121	$20.00
SOUND EFFECTS GENERATOR	SEPT 2012	09109121	$10.00
NICK-OFF PROXIMITY ALARM	OCT 2012	03110121	$5.00
DCC REVERSE LOOP CONTROLLER	OCT 2012	09110121	$10.00
LED MUSICOLOUR	NOV 2012	16110121	$25.00
LED MUSICOLOUR Front & Rear Panels	NOV 2012	16110121	$20 per set
CLASSIC-D CLASS D AMPLIFIER MODULE	NOV 2012	01108121	$30.00
CLASSIC-D 2 CHANNEL SPEAKER PROTECTOR	NOV 2012	01108122	$10.00
HIGH ENERGY ELECTRONIC IGNITION SYSTEM	DEC 2012	05110121	$10.00
USB POWER MONITOR	DEC 2012	04109121	$10.00
1.5kW INDUCTION MOTOR SPEED CONTROLLER (NEW V2 PCB)	DEC 2012	10105122	$35.00
THE CHAMPION PREAMP and 7W AUDIO AMP (one PCB)	JAN 2013	01109121/2	$10.00
GARBAGE/RECYCLING BIN REMINDER	JAN 2013	19111121	$10.00
2.5GHz DIGITAL FREQUENCY METER – MAIN BOARD	JAN 2013	04111121	$35.00
2.5GHz DIGITAL FREQUENCY METER – DISPLAY BOARD	JAN 2013	04111122	$15.00
2.5GHz DIGITAL FREQUENCY METER – FRONT PANEL	JAN 2013	04111123	$15.00
SEISMOGRAPH MK2	FEB 2013	21102131	$20.00
MOBILE PHONE RING EXTENDER	FEB 2013	12110121	$10.00
GPS 1PPS TIMEBASE	FEB 2013	04103131	$10.00
LED TORCH DRIVER	MAR 2013	16102131	$5.00
CLASSIC DAC MAIN PCB	APR 2013	01102131	$40.00
CLASSIC DAC FRONT & REAR PANEL PCBs	APR 2013	01102132/3	$30.00
GPS USB TIMEBASE	APR 2013	04104131	$15.00
LED LADYBIRD	APR 2013	08103131	$5.00
CLASSIC-D 12V to ±35V DC/DC CONVERTER	MAY 2013	11104131	$15.00
DO NOT DISTURB	MAY 2013	12104131	$10.00
LF/HF UP-CONVERTER	JUN 2013	07103131	$10.00
10-CHANNEL REMOTE CONTROL RECEIVER	JUN 2013	15106131	$15.00
IR-TO-465MHZ UHF TRANSCEIVER	JUN 2013	15106132	$7.50
"LUMP IN COAX" PORTABLE MIXER	JUN 2013	01106131	$15.00
L'IL PULSER MKII TRAIN CONTROLLER	JULY 2013	09107131	$15.00
L'IL PULSER MKII FRONT & REAR PANELS	JULY 2013	09107132/3	$20.00/set
REVISED 10 CHANNEL REMOTE CONTROL RECEIVER	JULY 2013	15106133	$10.00
INFRARED TO UHF CONVERTER	JULY 2013	15107131	$5.00
UHF TO INFRARED CONVERTER	JULY 2013	15107132	$10.00
IPOD CHARGER	AUG 2013	14108131	$5.00
PC BIRDIES	AUG 2013	08104131	$10.00
RF DETECTOR PROBE FOR DMMs	AUG 2013	04107131	$5.00
BATTERY LIFESAVER	SEPT 2013	11108131	$5.00
SPEEDO CORRECTOR	SEPT 2013	05109131	$10.00
SIDRADIO (INTEGRATED SDR) Main PCB	OCT 2013	06109131	$35.00
SIDRADIO (INTEGRATED SDR) Front & Rear Panels	OCT 2013	06109132/3	$25.00/pr
TINY TIM AMPLIFIER (same PCB as Headphone Amp [Sept11])	OCT 2013	01309111	$20.00
AUTO CAR HEADLIGHT CONTROLLER	OCT 2013	03111131	$10.00
GPS TRACKER	NOV 2013	05112131	$15.00
STEREO AUDIO DELAY/DSP	NOV 2013	01110131	$15.00
BELLBIRD	DEC 2013	08112131	$10.00
PORTAPAL-D MAIN BOARDS	DEC 2013	01113131-3	$35.00/set

(for CLASSIC-D Amp board and CLASSIC-D DC/DC Converter see offer above [Nov 2012/May 2013])

PRINTED CIRCUIT BOARD TO SUIT PROJECT:	PUBLISHED:	PCB CODE:	Price:
LED Party Strobe (also suits Hot Wire Cutter [Dec 2010])	JAN 2014	16101141	$7.50
Bass Extender Mk2	JAN 2014	01112131	$15.00
LI'l Pulser Mk2 Revised	JAN 2014	09107134	$15.00
10A 230VAC MOTOR SPEED CONTROLLER	FEB 2014	10102141	$15.00
NICAD/NIMH BURP CHARGER	MAR 2014	14103141	$15.00
RUBIDIUM FREQ. STANDARD BREAKOUT BOARD	APR 2014	04105141	$10.00
USB/RS232C ADAPTOR	APR 2014	07103141	$5.00
MAINS FAN SPEED CONTROLLER	MAY 2014	10104141	$10.00
RGB LED STRIP DRIVER	MAY 2014	16103141	$10.00
HYBRID BENCH SUPPLY	MAY 2014	18104141	$20.00
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	JUN 2014	01205141	$20.00
TOUCHSCREEN AUDIO RECORDER	JUL 2014	01105141	$12.50
THRESHOLD VOLTAGE SWITCH	JUL 2014	99106141	$10.00
MICROMITE QUICK VIDEO TERMINAL	JUL 2014	24107141	$7.50
FREQUENCY COUNTER ADD-ON	JUL 2014	04105141pb	$15.00
VALVE SOUND SIMULATOR PCB	AUG 2014	01106141	$15.00
VALVE SOUND SIMULATOR FRONT PANEL (BLUE)	AUG 2014	01106142	$10.00
TEMPMASTER MK3	AUG 2014	21108141	$15.00
44-PIN MICROMITE	AUG 2014	24108141	$5.00
OPTO-THERMOMETER MAIN BOARD	SEP 2014	23108141	$15.00
OPTO-THERMEMIN PROXIMITY SENSOR BOARD	SEP 2014	23108142	$5.00
ACTIVE DIFFERENTIAL PROBE BOARDS	SEP 2014	04107141/2	$10/SET
MINI-D AMPLIFIER	SEP 2014	01110141	$5.00
COURTESY LIGHT DELAY	OCT 2014	05109141	$7.50
DIRECT INJECTION (Di-) BOX	OCT 2014	23109141	$5.00
DIGITAL EFFECTS UNIT	OCT 2014	01110131	$15.00
DUAL PHANTOM POWER SUPPLY	NOV 2014	18112141	$10.00
REMOTE MAINS TIMER	NOV 2014	19112141	$10.00
REMOTE MAINS TIMER PANEL/LID (BLUE)	NOV 2014	19112142	$15.00
ONE-CHIP AMPLIFIER	NOV 2014	01109141	$5.00
TOR-DUINO	DEC 2014	08112141	$5.00
MULTISPARK CDI FOR PERFORMANCE VEHICLES	DEC 2014	05112141	$10.00
CURRAWONG STEREO VALVE AMPLIFIER MAIN BOARD	DEC 2014	01111141	$50.00
CURRAWONG REMOTE CONTROL BOARD	DEC 2014	01111144	$5.00
CURRAWONG FRONT & REAR PANELS	DEC 2014	01111142/3	$30/set
CURRAWONG CLEAR ACRYLIC COVER	JAN 2015		$25.00
ISOLATED HIGH VOLTAGE PROBE	JAN 2015	04108141	$10.00
SPARK ENERGY METER MAIN BOARD	FEB/MAR 2015	05101151	$10.00
SPARK ENERGY ZENER BOARD	FEB/MAR 2015	05101152	$10.00
SPARK ENERGY METER CALIBRATOR BOARD	FEB/MAR 2015	05101153	$5.00
APPLIANCE INSULATION TESTER	APR 2015	04103151	$10.00
APPLIANCE INSULATION TESTER FRONT PANEL	APR 2015	04103152	$10.00
LOW-FREQUENCY DISTORTION ANALYSER	APR 2015	04104151	$5.00
APPLIANCE EARTH LEAKAGE TESTER PCBs (2)	MAY 2015	04203151/2	$15.00
APPLIANCE EARTH LEAKAGE TESTER LID/PANEL	MAY 2015	04203153	$15.00
BALANCED INPUT ATTENUATOR MAIN PCB	MAY 2015	04105151	$15.00
BALANCED INPUT ATTENUATOR FRONT & REAR PANELS	MAY 2015	04105152/3	$20.00
4-OUTPUT UNIVERSAL ADJUSTABLE REGULATOR	MAY 2015	18105151	$5.00
SIGNAL INJECTOR & TRACER	JUNE 2015	04106151	$7.50
PASSIVE RF PROBE	JUNE 2015	04106152	$2.50
SIGNAL INJECTOR & TRACER SHIELD	JUNE 2015	04106153	$5.00
BAD WIRES INFRASOUND SNOOPER	JUNE 2015	04104151	$5.00
CHAMPION + PRE-CHAMPION	JUNE 2015	01109121/2	$7.50
DRIVEWAY MONITOR TRANSMITTER PCB	JULY 2015	15105151	$10.00
DRIVEWAY MONITOR RECEIVER PCB	JULY 2015	15105152	$5.00
MINI USB SWITCHMODE REGULATOR	JULY 2015	18107151	$2.50
VOLTAGE/RESISTANCE/CURRENT REFERENCE	AUG 2015	04108151	$2.50
LED PARTY STROBE MK2	AUG 2015	16101144	$7.50
ULTRA-LD MK4 200W AMPLIFIER MODULE	SEP 2015	01107151	$15.00
9-CHANNEL REMOTE CONTROL RECEIVER	SEP 2015	1510815	$15.00
MINI USB SWITCHMODE REGULATOR MK2	SEP 2015	18107152	$2.50
2-WAY PASSIVE LOUDSPEAKER CROSSOVER	OCT 2015	01205141	$20.00
ULTRA LD AMPLIFIER POWER SUPPLY	OCT 2015	01109111	$15.00
ARDUINO USB ELECTROCARDIOGRAPH	OCT 2015	07108151	$7.50
FINGERPRINT SCANNER – SET OF TWO PCBS	NOV 2015	03109151/2	$15.00
LOUDSPEAKER PROTECTOR	NOV 2015	01110151	$10.00
LED CLOCK	DEC 2015	19110151	$15.00
SPEECH TIMER	DEC 2015	19111151	$15.00
TURNTABLE STROBE	DEC 2015	04101161	$5.00
CALIBRATED TURNTABLE STROBOSCOPE ETCHED DISC	DEC 2015	04101162	$10.00
VALVE STEREO PREAMPLIFIER – PCB	JAN 2016	01101161	$15.00
VALVE STEREO PREAMPLIFIER – CASE PARTS	JAN 2016	01101162	$20.00
QUICKBRAKE BRAKE LIGHT SPEEDUP	JAN 2016	05102161	$15.00
SOLAR MPPT CHARGER & LIGHTING CONTROLLER	FEB/MAR 2016	16101161	$15.00
MICROMITE LCD BACKPACK, 2.4-INCH VERSION	FEB/MAR 2016	07102121	$7.50
MICROMITE LCD BACKPACK, 2.8-INCH VERSION	FEB/MAR 2016	07102122	$7.50
BATTERY CELL BALANCER	MAR 2016	11111151	$6.00
DELTA THROTTLE TIMER	MAR 2016	05102161	$15.00
MICROWAVE LEAKAGE DETECTOR	APR 2016	04103161	$5.00
FRIDGE/FREEZER ALARM	APR 2016	03104161	$5.00
ARDUINO MULTIFUNCTION MEASUREMENT	APR 2016	04116011/2	$15.00

NEW THIS MONTH

PRECISION 50/60HZ TURNTABLE DRIVER	MAY 2016	04104161	$5.00
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ASK SILICON CHIP

Got a technical problem? Can't understand a piece of jargon or some technical principle? Drop us a line and we'll answer your question. Send your email to silicon@siliconchip.com.au

Speed controller for mobility scooter

I recently purchased a mobility scooter but the motor controller was faulty and failed during the first ride. Where can I obtain a circuit diagram for a 24V DC brush-motor controller that could be used to replace the original unreliable unit?

Your help would be greatly appreciated. (R. M, Buderim, Qld).

● We published a 12/24V 20A Motor Speed Controller in June 2011. Kits are available from Altronics (K6007) and Jaycar (KC5502). We can also supply the PCB for this project – see our website for details. This may be suitable provided the scooter does not require over 20A.

External antenna for mobile phones

These days mobile phones tend to have no external antenna jack but if I understand correctly, the signal may be inductively coupled to an external antenna via in-car hands-free kits. I note that inductively-coupled units are also available that simply attach to the phone case using Velcro straps.

I have a late model Windows phone which I take with me to various campsites. However, in some of these sites, phone reception is too poor for reliability. Could this be the basis of a project, ie, a portable inductive coupling unit for smartphones, given the amount of these devices about nowadays? (T. I., Penguin, Tas).

● In principle your idea is good: get a car cradle with inductive coupling and then feed it to an external antenna. But unfortunately, you cannot use a generic cradle because it will not necessarily work with your particular mobile phone. Cradles with inductive coupling are quite expensive and then you have to add in the cost of the antenna. Most people do not bother with them, even though they may have a "hands-free" kit in their cars.

Nor can you expect mobile phone coverage in many remote parts of Australia. 4G & 3G coverage maps from Telstra and other companies can be used as a guide but they might not give any indication of the reception holes that could occur at your chosen camp site.

Telstra does have "blue-tick" recommendations for mobile phones with good remote area reception but typically they are the more expensive models.

We hate to give such a negative answer but in our experience, most campers tend to climb the nearest hill to try and get the best reception in remote locations. Otherwise, it is just a matter of enjoying the solitude.

Wideband oxygen sensor air/fuel display

I have a question regarding the Wideband Oxygen Sensor Controller published in the June 2012 issue. Specifically, if the unit is properly calibrated and shows the correct air/fuel ratio for an engine running on petrol, does the unit have to be recalibrated to show the correct air/fuel ratio for an engine running on 10% ethanol?

For example, if your engine was operating at a stoichiometric air/fuel ratio using petrol, the display would show "14.7". If the same controller was used on a second engine operating at a stoichiometric air/fuel ratio using 10% ethanol, would the display show "13.8?" (G.D., Arizona, USA).

● The display can be set to show the Lambda value or air/fuel ratio value. You can set the display to show the range of air/fuel ratio values you wish. So you can set the display to show 13.8 at stoichiometric. It will not automatically change depending on what fuel you are using, so if the fuel blend could vary, showing the Lambda value is your best option.

Garbled Programmable Ignition display

Can you please tell me how to make the screen display in English? Language settings are not covered in the manual provided. (A. B., via email).

● The screen display should be in English. If it shows strange characters then there is likely to be a problem with the DB25 connecting cable or the connector soldered to the PCB. Check

Single-Ended Valve Amplifier Output Transformer

Have you ever published any articles on using line transformers as output transformers for single-ended valve output stages?

I would expect that you would have to dismantle the transformer and rebuild it so that a small air gap could be introduced between the "E" and "I" laminations.

I need such a device to repair a small mains mantel set with an open circuit primary on the output transformer. (R. M., via email).

● We have presented a 20W per channel single-ended valve amplifier but the technique used to capacitively couple the output signal to the line transformer would not be relevant to your query.

To learn more, have a look at the Mudlark Valve Stereo Amplifier in the August & September 2005 issues. You can see free 2-page previews of the article at www.siliconchip.com.au/Issue/2005/August/The+Mudlark+A205+Valve+Stereo+Amplifier and at www.siliconchip.com.au/Issue/2005/September/The+Mudlark+A205+Valve+Stereo+Amplifier%2C+Pt.2

As for your repair job and providing an air gap between the "E" & "I" laminations, to stop DC saturation of the core, that may not be possible with some line transformers if their laminations are welded together.

that the connector cable has continuity through from pin 1 to pin 1, pin 2 to pin 2 etc. Similarly, check that the connectors on the PCB are properly soldered to the PCB without any dry (open circuit) connections. Tarnished pins on the connectors can be difficult to solder.

Note that the display PCB has a wire link near the connectors that needs to be inserted and soldered.

Speed display for variable speed drive

After wanting to learn more about electronics I subscribed to SILICON CHIP. I recently built the 1.5kW Variable Speed Drive kit from Altronics (Induction Motor Speed Controller, SILICON CHIP, April & May 2012). As my first kit it was pretty cool to build something that I use as an electrician.

I noticed that my PIC chip was shutting down the IGBT chip by giving a high signal on pin 25 when the onboard speed pot was turned down low. I was only using a phase rotation meter to test it, not an actual induction motor. Is this normal?

Also, I would like to display the frequency of the drive in a remote box on the front of a lathe. Could you guys design something to wire straight into the VSD output terminals but be mounted internally in the VSD enclosure with isolated output wiring going to the remote box?

It would also be handy if there was an RPM display on the remote box using maybe a VR, optical or Hall effect sensor to pick up the lathe spindle speed. (R. B., via email).

● We're not sure how the VSD would behave when driving a phase rotation meter. You should try it with an induction motor to test it properly.

We published a brief description about reading the frequency output of the VSD in the September 2014 issue. Briefly, it involved connecting a 9V or 12VAC plugpack to the output and connecting an RC network consisting of a 10kΩ resistor and 100nF capacitor across the plugpack's low voltage output, to reduce the high frequency hash from the VSD. You can then read the signal with a frequency meter, an oscilloscope or with a DMM which reads frequency.

On the other hand, if you wanted to read the RPM of your lathe, you would need a tachometer with an optical pick-up and we described such a unit in the August and September 2008 issues. You can see a free 2-page preview of the first article at: www.siliconchip.com.au/Issue/2008/August/LED+Strobe+%26+Contactless+Tachometer

Or you can purchase the full issue from our on-line shop at www.siliconchip.com.au

DAB+ Whip Antenna Wanted

Thanks for your recent articles on a DAB+ antenna, something I really need. Fading is chronic at certain times of the year here. Just changing my position slightly in bed is enough to cause fading.

I have a Sony receiver that will receive all stations except the ABC and SBS, which are the ones I want. I still have a problem though, since I have DAB+ receivers in four places in my house. How do I get the antenna output to each of these radios, especially given the majority have no external antenna inputs?

I can't imagine running cables through the roof and to wall sockets in each room. I need something to re-broadcast or distribute the antenna output to give a strong signal within my house.

There might be a commercial product to do this but I can't think of one. Any ideas? (P. C., Jindalee, WA).

● You have probably seen the info panel we had in the DAB+ antenna article in November 2015, about fitting a whip antenna to typical DAB+ radios. However, that is not a practical solution if you have multiple radios in different rooms.

One possibility is to build the DAB+ antenna and mount it on your roof and then feed its signal via a coax cable into a whip antenna inside your house. It should radiate enough signal to give better reception to those radios without external antennas.

If that is not enough, maybe you could feed the external DAB+ signal to a booster amplifier and then use that to drive the whip antenna in your house.

Speech timer LED question

I have built the Speech Timer from the December 2015 magazine and it works a treat in all modes except my understanding of how to set the green, amber and red warning LEDs when the unit is in count-up mode from 0:0. The timer counts up OK but I am unable to program the LEDs.

When using the unit in count-down mode, I am able to set the LEDs to times as determined by me. The table on page 70 suggests that they can be set "when selected". Your help would be appreciated. (R. L., Murray Bridge, SA).

● You can only manually set the green, amber and red LEDs to light when using the manual 0:0 count-up mode. That's the first mode shown in Table 1. The remaining modes have the LED lighting times preset, ie, Speech 1-10 and the Toastmasters LED settings are fixed.

If you want to have the warning LEDs light, you can only do this while the timer is running. That's done by pressing the "C" button at the time each LED is to light. The green LED will light when the "C" button is first pressed. The next press will light the amber LED and the final "C" press will light the red LED; ie, it's not automatic and you can't set these times beforehand.

The reason why the LEDs can be set in the count-down mode is because the up and down buttons can be re-tasked to perform timer count-up and count-down functions. However, in count-up mode, they are used for changing the actual mode. There just aren't sufficient buttons to do the same adjustments in count-up mode as in the count-down mode.

Using the HEI with positive ground

I have used a High Energy Ignition kit from Jaycar (November/December 2012 issues) with great success. I have since moved into older cars which have positive ground electrical systems.

Can the High Energy Ignition system be modified for use in vehicles with this type of system? Some owners of English cars don't want to change over to a negative-ground system as they wish to keep the original radios. (F. J., Bray Park, Qld).

● We published a positive-ground modification for our earlier High Energy Ignition (HEI) design in the No-

Micromite LCD BackPack Locked Up

I've assembled the Micromite LCD BackPack kit without problems. On first run I got the greeting from the console and it accepted my commands. Next, I entered in the command to configure the LCD as shown in the magazine, ie: "OPTION LCDPANEL ILI9341, L, 2, 23, 6" (enter).

It said something about pin 23 being invalid. I checked the track on the PCB; it goes to the reset line on the LCD.

The manual implied that any free pin can be used so I re-tried the above command with pin 25 instead. Now, no commands are accepted and all I get is: CPU exception #7 and processor restarted.

How do I fix it? I know the chip could be reprogrammed but don't have a PIC programmer. Please help. (B. J., Narre Warren, Vic).

● Geoff Graham responds: the probable reason for the error message that you received was that it was previously configured for some other use or that you mistyped the command.

The manual does say that any free pin can be used for the RESET signal but pin 25 was not free – it is the clock signal used for the SPI channel to communicate with the LCD. Using pin 25 would not have worked anyway as it is not connected to the LCD reset signal (which is pin 23, as you pointed out).

It seems that your Micromite is now stuck in a loop where it is trying to set up the SPI channel (which it does) but then hits a problem trying to set up pin 25 as RESET which is already in use for the SPI.

The solution is to perform a reset on your Micromite. This is explained on page 16 of the user manual as follows: MMBasic can be reset to its original configuration using either one of two methods:

(1) The chip can be reprogrammed with the Micromite firmware using a PIC32 programmer; or

(2) Sending a stream of exclamation marks (!) to the console Rx pin at 34800 baud at start-up. If 30 of these characters are received in the first two seconds the Micromite will reset itself.

This can be accomplished by simply setting the terminal emulator to 38400 baud and holding down the exclamation key while powering up the Micromite (on most keyboards this requires holding down shift and the number one key). If the reset was successful the message "MMBasic reset completed" will display on the console.

Either method will result in the program memory and saved variables being completely erased and all options (security PIN, console baud rate, etc) will be reset to their initial defaults.

Note: the original error turned out to be due to a PIC32MX270 chip being accidentally supplied rather than a PIC32MX170. Pin 23 is not available as an I/O on this chip.

vember 1997 issue (see Ask Silicon Chip on page 90 of that issue).

Similar changes can be made to the November/December 2012 ignition system. You would need to wire the ignition coil (and ballast resistor, if used) between the positive rail and IGBT collector as in the original circuit but with the metal case of the HEI connected to the vehicle chassis (positive) instead of the negative. The negative supply for the HEI would need to be wired separately to the negative supply of the vehicle.

The only remaining issue then is how to trigger it. If using points, you could insulate the points from the positive chassis using a mica washer and insulating bush so that the points can be rewired to switch the negative supply. Alternatively, use the additional input transistor circuit shown in the November 1997 issue (mentioned above) to invert the points signal sense.

If using a Hall Effect trigger, optical trigger or reluctor, these are invariably intended for use in negative chassis vehicles. So it may be necessary to isolate the trigger unit from the positive chassis if the trigger unit obtains its negative supply via connection to the chassis.

Hall Effect and optical pick-ups often have the three separate wires (positive, negative and signal) brought out and isolated from the chassis connection so these should not be an issue. Some reluctor units will only have one wire with the chassis connection tying the other coil end of the reluctor trigger to the negative supply. This would need to be isolated and the reluctor case tied to the negative supply separately.

The November 1997 back issue is available for purchase from the Silicon Chip website.

Evaporative cooling fan speed control

Recently, I have been enquiring about purchasing a roof-mounted evaporative air conditioner. They have a single-phase fan motor with an associated capacitor, about 25µF. Typically they provide 10 fan speeds, and some boast 100 speed settings. How do they achieve this speed control? (A. D., Erskine, WA).

● Usually speed control is done with a variable voltage, either with phase control using a Triac (see the circuit published in our January 1990 issue) or linear voltage control (May 2014). Another method is to add inductance in series with the motor but that's not likely to be practical for 100 speed settings.

Running the Voltage Switch from 24V

I am interested in building the Universal Voltage Switch from a Jaycar kit. Can you tell me if it will operate with a 24V supply or will this need to be lowered? It will have a switching voltage of 13V. (S. F., via email).

● The Voltage Switch is designed to run from a 12V supply (up to 14.8V) and can operate with a 13V threshold setting. You could use a 24V supply (up to 29.6V) by changing the 100µF 16V and 10µF 16V capacitors to 35V types, while ZD1 would need to be changed to 30V 1W. In addition, change the 10Ω resistor to 100Ω 1W, change the 1.8kΩ resistor in series with LED1 to 3.3kΩ 0.5W and use a 24V DC coil relay (eg, Jaycar SY-4053).

Adaptor for bench power supply

I am contemplating the construction of a 40W bench power supply, as

shown in the April 2014 issue. I have an AC/DC adaptor with an output of 12V @ 3A. Will this be sufficient as a power source? (N. S., via email).

● While the power supply would operate with a 12V 3A adaptor you would be able to easily exceed its ratings at higher output voltage settings from the bench supply. What would happen then depends on the type of supply: it may switch off briefly or it may overheat and ultimately be damaged. Either way, the output of the bench supply would probably drop under load and it may oscillate, potentially overheating or causing other problems.

It would be safer to use an adaptor which can supply more current at 12V. However, it is possible that if you are careful in how you use the supply and only require modest output current, you may be able to get away with it.

Turbo Boost Controller pressure control

I'm interested in buying the *Performance Electronics for Cars* book, in order to build the Turbo Boost Controller but I can't find sufficient information to determine whether it would suit my application. Does it measure the actual amount of boost that is produced with a pressure sensor, or just a pressure ratio to the fuel injection amount? I want to be able to set a desired boost pressure. (E. P., Sofia, Bulgaria).

● The only input to the IEBC (Independent Electronic Boost Controller) is the injector signal. The whole range of boost pressures can be mapped according to boost pressure readings during controller set-up. So in effect the pressure is measured but using the injector duty cycle signal as a proxy. There is no direct pressure reading input to the IEBC.

Query on the Battery Lifesaver

A couple of days ago I purchased a Battery Lifesaver kit from Jaycar (KC-5523) in New Zealand. This was published in your September 2013 issue. It comes pretty much pre-assembled, requiring only the addition of the zener diode and the resistors for the required cut-out voltage.

After assembling it I found it did not perform as I expected. I came to the conclusion that the regulator was not working correctly. I assembled the second kit only to find that while the regulator in that one seems to work, it still does not operate as expected.

When a voltage above 5V is supplied, the regulator output pretty much sits on 5-5.1V. However, despite adding the diode and resistors as specified, it never reaches the point where the voltage on pin 3 of IC1 goes below the voltage on pin 2, thus shutting off supply.

I am using an 8.2V zener diode with RL = 2.7MΩ, RU = 5.6MΩ and RH = 22MΩ. I'm intending for the supply to shut off somewhere between 15.5V and 17.1V. Adjusting the trimpot seems to make no difference to the voltage on pin 3. With a 15V input, pin 2 of IC1 is at 5V while pin 3 is at 6.8V. However, if the input is lowered to 12V, pin 2 is at 4.0V while pin3 is at 4.1V.

If you can shed any light on why this isn't working as it should, I'd appreciate any help you can give. (A. S., via email).

● With RU = 5.6MΩ and RL = 2.7MΩ, you should have a voltage at pin 3 much lower than you have described. For example, with a 15V input and VR1 at minimum resistance, we would expect pin 3 to be at 4.88V, or 4.35V with VR1 at maximum resistance. Are you sure you didn't get RU and RL mixed up?

Check also that all of IC1's pins are properly soldered. Ideally, do a continuity check between the pins on the package and components on the PCB that they should be connected to. Visual inspection with a magnifying glass would also be a good idea.

Using Jacob's Ladder for oil burner ignition

I recently built the latest Jacob's Ladder design but not for its intended purpose. My friend has a scale steam engine which he is converting from coal to oil-fired (the coal burner produces a lot of soot). We have adapted the electrodes from a Karcher high-pressure washer to the fire-box and tried the system to see how it works.

We have had reasonable success

Auto-Starting TightVNC On Raspberry Pi

I am currently working through your temperature, pressure and humidity sensor project from the January 2016 magazine. Everything has been progressing well, until I get to page 26, in the "Running it headless using TightVNC" section.

I'm up to the paragraph: "we now want TightVNC to automatically start when the system is booted. To do that, run **sudo leafpad** from the Terminal, create a new file called **vncserver.service** in **/etc/systemd/system** and add the following code . . ."

I was hoping you may be able to provide further detail on this step for me as I'm a bit new with the OS. At this stage, I'm unable to save the code to **/etc/systemd/system**, as it doesn't come up as a save option.

Perhaps I'm using the wrong program but I'm not entirely sure on how to create the file and save it in this location.

I thought I was on the right track when I managed to find **/etc/systemd/system** in the file manager, however it's under the / folder in the directory tree and it's saying that I don't have permission to put files in that destination.

I then tried running the next few commands, just in case:

```
sudo chown
sudo chmod
sudo systemctl
```

but was told that I'm missing the operand.

Any further information would be greatly appreciated; even an idiot's guide would be great. (X. N., Holsworthy, NSW)

● What you need to do is to use the Leafpad text editor to create a file called **vncserver.service**, enter the code into that file and save this in the **/etc/systemd/system** folder.

That's done by first opening a terminal window and entering the following commands to launch Leafpad as a super user:

```
xhost +
sudo leafpad
```

When Leafpad opens, click the "File" menu, select "New" from the drop-list (to create a new file) and enter in the code. Then click "File", select "Save As" from the drop-list, navigate to the **/etc/systemd/system** folder, name the file **vncserver.service** and click the Save button.

That's it – TightVNC should now start automatically at boot (reader feedback: that did the trick).

Capacitor Discharge Ignition For An Outboard Motor

My Tohatsu 9.9B outboard motor does 5400 RPM at wide open throttle (WOT). It's a 250cc twin cylinder with a single twin-tower HT coil (wasted spark ignition) feeding two spark plugs.

The original CU15 Capacitor Discharge Ignition (CDI) has died and it's around $400 to replace so I bought two of your CDI kits from Jaycar, one to replace the broken unit and one as a spare. I calculate that it requires 12,000 sparks at 6000 RPM which is 200 sparks per second or 5ms between sparks. Your article, at http://archive.siliconchip.com.au/cms/A_110499/article.html states "If C1 is 1µF, then it will charge in about 350ms – much quicker than the time between sparks, even in a high-revving engine." Does this mean the CDI unit is not suitable for use with my engine?

I am about to assemble the kit; will your system work OK? (D. P., Christchurch, NZ).

● You have been looking at our legacy website and unfortunately the article has been mangled.

The original text in fact said "If C1 is 1µF, then it will charge in about 350µs – much quicker than the time between sparks, even in a high-revving engine". So you can see that this should not be a problem with your motor. You will have to try it to find out for sure but we expect that it will work.

Note that the article is also available on our new website at www.siliconchip.com.au however you would need to purchase online access to view the relevant page. The article is transcribed correctly on the new site. We may be shutting down the legacy site soon to avoid this type of confusion, since all the same content is now available on the new site.

but I was wondering if it is possible to get more zap in the spark.

Is there some way of providing a harder whack to the coil to provide a more robust spark? We do not need rapid firing as in a car; 20 sparks per second would be ample. I tried adjusting the dwell trimpot (VR1) and also adjusted the electrode gap but the spark energy is still not as high as I'd like.

By the way, I have enjoyed your magazine for many years and will continue to do so. (P. A., Yinnar, Vic).

● The limitation in spark energy is the ignition coil. Assuming the dwell has been set to optimum, the only way to get more energy is to use a higher output energy ignition coil or increase the supply voltage.

The latter method may cause the coil to fail due to excess current or overvoltage; see http://dtec.net.au/Ignition%20Coil%20Energy%20Testing.htm for some relevant testing done on various ignition coils.

Beam-Break Flash Trigger sensor problems

I am constructing the Beam-Break Flash Trigger from the June 2009 article and I am having trouble with what should be a simple device. As soon as I switch the unit on, the green LED lights and I can measure 0.7V at the base of Q1. Measuring around the circuit, I discovered 8.25V on pin 7 of IC1, the LM358. I have replaced IC1 and PD1 twice but these voltages remain the same. I have also measured 1.09V on pin 2, 1.07V on pin 5 and 0.37V on pin 6 of IC1.

I removed IC1 and measured the socket voltages. Pin 7 was at 0.2V. The PCB was made using the pattern on the SC website and I have checked for any errata but didn't find any.

I have measured the values of all components and they appear to be correct. The ZD1948 infrared sensors were purchased from Jaycar but they have no markings on them so I cannot tell if I have been supplied the correct item.

Covering the ZD1948 with aluminium foil to simulate the absence of infrared made no difference. The circuit description suggests that the voltage at pin 7 with no infrared signal should be between 1.7V and 4.0V. Clearly I cannot get this voltage but I am at a loss as to explain why. (B. D., Hope Valley, SA).

● Have you checked the polarity of PD1? Maybe it is connected the wrong way around *(note: this was confirmed as the problem. It appears that the product now being supplied has its anode and cathode pins reversed ,compared to the one used in the original prototype).*

Using USB TV dongles to find a digital signal

I travel our great country in a motor home. Now that analog TV signals are gone, I am forced to search for a digital TV signal by rotating my antenna. It is a hit and miss process. Once a signal is received, I can rotate the antenna further to increase the signal strength. But sometimes we just give up, as searching in different directions produces no results.

We have tried signal strength meters without success, some with a rows of LEDs and one with an analog meter similar to the type used for setting up a satellite dish.

Could you design a project to sense a TV signal from any direction and rotate the antenna to maximise the signal? It would ideally include a gain control and an LCD readout. Could it be done using a PICAXE?

Keep up the good work. (J. V. E., Wishart, Qld).

● Check the answer given to R. W. on page 90 of the February 2016 issue (Ask Silicon Chip). Basically, we suggest you use a USB TV dongle plugged into a laptop to monitor signal reception while rotating the antenna. Then once you have found a signal, you can connect the antenna to your TV.

Valve preamp LED brightness

I built the Stereo Valve Preamp from the January & February 2016 issues and am very happy with it. However, the green and red LEDs on my unit differ quite markedly in brightness. I understand that different colour LEDs have different intensities and the current going through them also makes a big difference.

I would like to increase the intensity of the red LED. The voltage readings are 1.97V for green and 1.84V for red. I was thinking of either reducing the 220kΩ series resistor to 180kΩ or putting a 1MΩ resistor in parallel with the 220kΩ resistor. Any suggestions? (J. B., Toowong, Qld).

● LEDs sometimes do require current limiting resistor value tweaking as they vary in efficiency between dif-

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Ask SILICON CHIP

. . . continued from page 102

ferent types and even between individual LEDs in a batch. We can't see any problems with what you are suggesting. The 220kΩ resistor gives LED2 a little under 1mA. The design assumes it has a fairly high efficiency to give sufficient brightness with so little current, which is true of many red LEDs but perhaps not yours.

There are two limits on how low a resistor value you can use: the LED's current rating and the resistor's power rating. The LED current rating would not be exceeded unless the resistor value was less than 22kΩ so that is unlikely to be a problem.

The resistor dissipation is going to be roughly $265V^2 \div R$. That's 320mW for the specified 220kΩ resistor, which has a rating of 1W. So you could reduce the value to as low as 100kΩ, resulting in a dissipation of around 700mW. That would more than double the LED current and should increase the brightness sufficiently.

You can use 180kΩ or the parallel 1MΩ resistor if you only need a slight increase in brightness. If you use the parallel resistor approach, make sure

Notes & Errata

Automatic Starter Circuit For Cars, Circuit Notebook, April 2016: as noted in the Mailbag pages of this month's issue, if this circuit is added to any car it brings about a dangerous situation whereby the car's engine could be inadvertently be started in any gear. We cannot recommend that anyone install this circuit on their car.

Ask SILICON CHIP

. . . continued from page 103

it's rated for at least 250V DC. Not all 0.25W resistors would necessarily withstand this. If that still isn't bright enough, maybe try 150kΩ or parallel the existing 220kΩ resistor with a 470kΩ resistor.

Deep cycle charger not working correctly

I built the Charger for Deep Cycle 12V Batteries from the November & December 2004 issues, mainly because I had a suitable transformer. But it has a problem: when I push the Start button it shows the battery type, as if I had pushed the Set button. I have checked all wiring and the circuit board, especially around the switches and display. Everything else is OK and all voltages measure as correct.

When programming the PIC, I initially used pin 4 as V_{DD}, as shown on the circuit. As it did not work, I then connected pins 4 & 14 to +5V and ultimately, after checking the data sheet, I got it right and used pin 14. The chip then programmed OK but I feel as if this is where the fault may lie.

Do you think I should get another PIC or could it be something else? (P.C., Balgal Beach, Qld).

- It is unlikely the PIC is damaged. Make sure you have the 1nF capacitor connected to ground from the common switch connections. Check that diodes D7-D9 are connected the right way round.

If it still doesn't work properly, you could try a new PIC.

Using a GPS module with an enable pin

I bought and am installing a VK-2828U7G5LF GPS module in the Accurate GPS 1PPS Timebase for Frequency Counters (SILICON CHIP, February 2013).

The data sheet link for this model states that the yellow lead is designated as "Power Enable", a point not mentioned in your original article (and so I assume it is peculiar to this later model unit, which also includes status LEDs and is certainly faster). Can you advise me where to terminate this lead? (P.S., Warwick, Qld.)

- As noted in the data sheet PDF with respect to the Power Enable pin: "a high level means that the module works, low level means the modules (sic) is closed". Therefore, you should connect the Power Enable pin to the +3.3V or +5V supply, depending on what you are using for the circuit. SC

Next Issue

The June 2016 issue of SILICON CHIP is due on sale in newsagents by Thursday 26th April. Expect postal delivery of subscription copies in Australia between May 26th and June 3rd.

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